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PURDUE
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THE APPLICATION OF THE PNEUMATIC CAISSON TO CONCRETE MINE SHAFTS.

W. F. Collar, '04.

The advantages of compressed air in caisson work were well known in this country forty years ago. As early as 1870 the pneumatic caisson was well enough developed to be employed in the construction of the Eads bridge across the Mississippi river at St. Louis. Later in 1884, the same principle was employed in the building of the piers of the Baltimore and Ohio railway bridge at Havre de Grac, Md. Previous to this time pneumatic piles were used, but the practice of using compressed air to hold back water in excavations below the water level was not general. The method has now been developed to the point where it is successfully applied to the construction of foundations of large buildings, dams, tunnels, intakes for water works, light houses, and mine shafts. The simple pneumatic caisson is a metallic box without an enclosing wall at the bottom, sunk in the water or earth. Air is introduced into the box until the pressure is sufficiently great to prevent the water from entering the box from the bottom. This pressure must be high enough at all times to overbalance the hydrostatic head of water minus the loss in the head due to the frictional resistance of the surrounding material opposing the flow of the water into the caisson.

Although one of the original uses of the pneumatic process was in mine shaft construction, its employment in this field has been general in this country only during the past ten years. It has been brought to the highest state of development in the Lake Superior iron mining district, on

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the Marquette, Menominee, Missabe, Vermillion, and Cuyuna Ranges. With few exceptions, the shafts sunk in this region have been made of re-inforced concrete, some of which are circular both outside and inside, while others are circular outside and rectangular inside. In all cases, a steel cutting edge made in the form of a cylinder by joining plates and angles is fastened to the inside circular or rectangular section. The forms for the concrete consist of light steel plate on the outer side of the wall and wooden forms on the inner side. Both sets of forms are interchangeable so that three sets are usually used to permit the lower part of the concrete to set thoroughly while concrete is being poured in above. After the cutting edge is set up and the walls built up ten or fifteen feet, the excavation is begun. The material through which the shaft is to be sunk is removed by clam shell or orange peel dredges. As the excavation progresses and the concrete wall is built up, the mass of the concrete becomes great enough to cause the shaft to sink as a unit. This method is continued until the

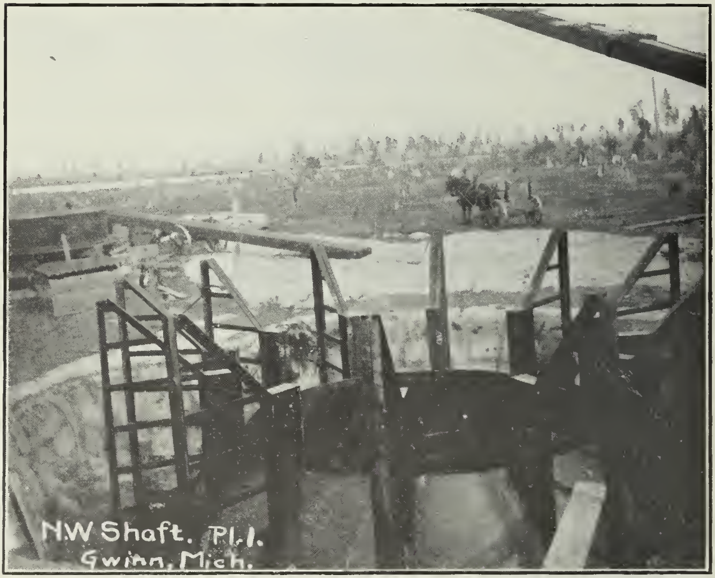


Fig. 1.

Steel Cutting Edge Being Erected.

weight of the shaft is no longer great enough to overcome the external frictional resistance between the wall and the earth, or some hard substance as rock stops the action of the cutting edge.

When this point is reached, preparations are made for applying the pneumatic method. A deck is constructed over the top of the shaft so as to form a working chamber below. This deck rests in a notch in the concrete that is eight to ten inches deep. Three courses of 12″x12″ fir or yellow pine timber are placed with the ends in this notch alternately crosswise and lengthwise of the opening. The ends of the timbers are wedged in the notch with hard wood wedges. The deck is sealed with three inch planking on the under side and the cracks are caulked with oakum. Grout is then poured around the top edges of the timber to make the joint as air tight as possible. Openings are left through the deck for the air lock, the four inch air shafting, the two four inch air lines, and for the one inch line for signals.

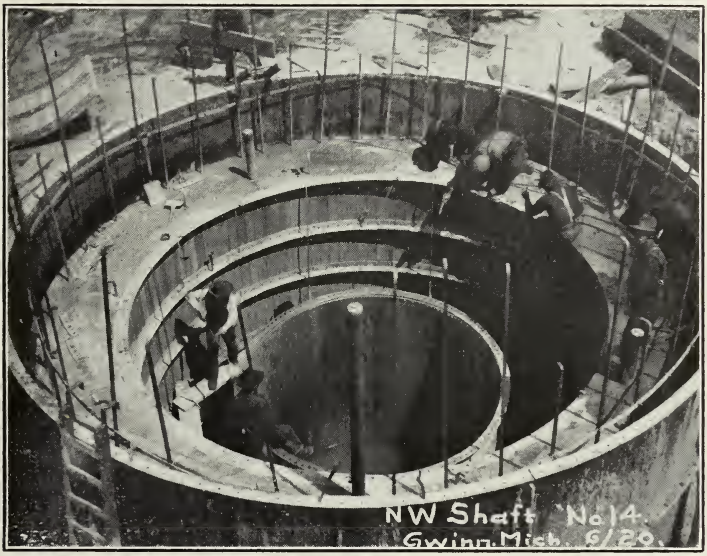


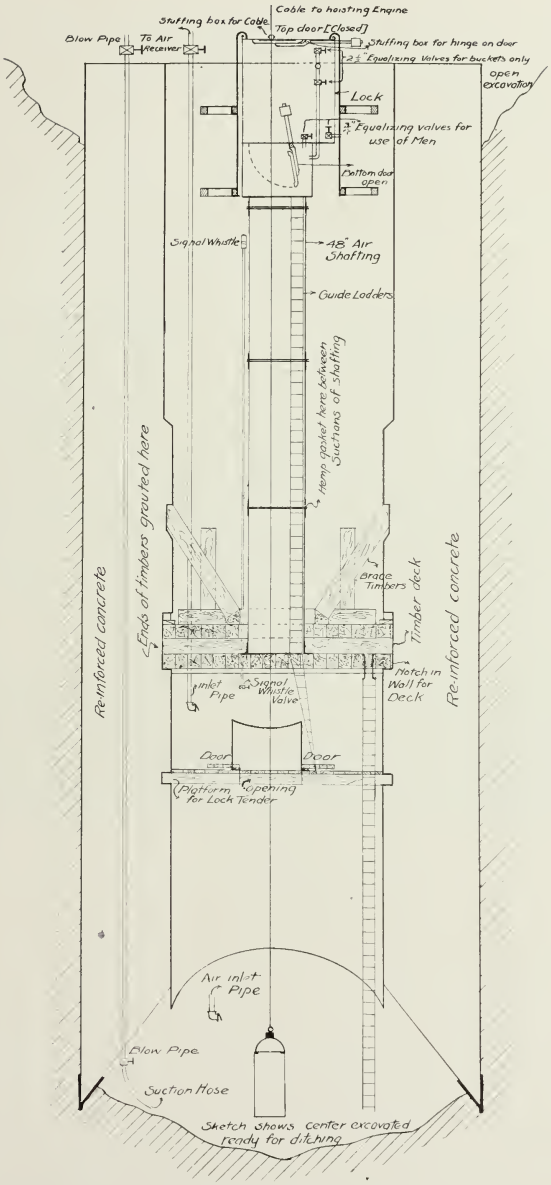
Fig. 2.

Circular Outside and Inside Design.
Showing Forms, Re-Inforcing, Dredge Well, and Air Lines.

The air shafting, made of half inch plate four inches in diameter, is caulked for sixty pounds pressure. Guide ladders and connecting flanges are provided for joining one section to another. The air lock is that known as the Moran Patent. It is circular or horse-shoe shape in form, and has hinged doors placed eccentric with each other in the top and bottom diaphragms of the lock. Levers operate these doors through stuffing boxes in the side of the lock. At the edge of the door in the top diaphragm and directly over the center of the door in the bottom diaphragm is placed a stuffing box through which passes a cable from the derrick boom to the working chamber below. Material is taken in and out of the caisson by this cable. Two sets of equalizing valves are used—one large set on the outside of the lock and one small set on the inside. The medical lock which is a comparatively new device in this work is a two compartment apparatus fitted with special valves.

In starting the work with the air, the top door is held down and air is pumped into the shaft. In ordinary ground, the water is driven down, but sometimes it is necessary to pump it out. If the excavated material is of such nature that it can be blown out, it is handled in this manner, but usually it is taken to the surface in buckets. The customary procedure is to excavate in the center and leave a small bank around the cutting edge. The shaft is then "ditched," that is, the bank is thrown into the center. If after ditching the shaft does not settle, the air pressure is reduced slowly or rapidly as the conditions may require. Sometimes with the reducing of a few pounds the shaft will drop slowly, and other times it is necessary to release all the air. Occasionally it is necessary to apply an eccentric load of sand or pig iron to make the shaft settle straight. The progress of the sinking varies with the material almost entirely until the depth reaches a point where a heavy pressure is required and the actual working time is greatly diminished. The building of the walls on top and the sinking of them are carried on at the same time. As much as five and six feet have been constructed in a period of ten hours, but two or three feet is a good average unless rock is encountered.

Shaft work is quite different from foundation work for structural purposes, in that it is not so much that the rock ledge is required for a foundation, but that a water tight joint be made with the ledge so as to shut off the sur-



DRAWING OF SHAFT
showing arrangement of lock, air lines, shafting, deck, platforms, braces for deck etc. etc.

Fig. 3.

face water and the fine sand as the shaft is sunk through the rock. To secure a water tight joint it is often necessary to excavate through the decomposed top surface of the rock to a depth of ten or fifteen feet. Some of the conditions that are often encountered and must be overcome are large cracks in the rock, clay seams, and an angle in the ledge. In making the final seal, the rock is excavated below and outside of the cutting edge. This excavation is filled with concrete which is built up to conform with the inside section of the shaft. The average size of the interior section of the shaft is fourteen feet ten inches by ten feet ten inches, but it may vary with the deposit and amount of ore to be mined annually.

The length of time men may work in the compressed air has been determined with great care, and if the few advised precautions are observed, comparatively few men are overcome in the ordinary pressures. The following scale of working hours is usually in force:

1 8-hr. shift for 22 pounds and under, ½-hr. for lunch.
2 3-hr. shifts for 23 to 30 pounds.
2 2-hr. shifts for 31 to 34 pounds.
2 1½-hr. shifts for 35 to 38 pounds.
2 1-hr. shifts for 39 to 42 pounds.
2 45-min. shifts for 43 to 45 pounds.
2 40-min. shifts for 46 to 50 pounds.

After thirty-nine pounds pressure is reached, the minimum time of decompression requires twenty-five minutes.

The scale of hours differs materially, depending upon the nature of the work. Where large caissons are being sunk and where man and material locks can be used, the scale of hours may be increased as the time of decompression may be increased without impeding the progress of the work. Stage decompression is employed in tunnels and the hours are lengthened. Physical examination is usually required of men who are not accustomed to air pressure. Men who take care of themselves, have moderate habits, and pay attention to the time of decompression, have very little trouble standing the air pressure for long periods of time. Some of the men who worked on the Havre de Grace bridge are still following the same line of work.

Caisson disease, as the effect of air on the body is called, is a very strange disease and at the present time is causing much interest. The air pressure effects men in a variety of ways. It is the general opinion that prevention is the only positive cure and that slow decompression is imperative. The generally accepted theory is that the excess air pressure assimilated by the body forms air bubbles in the tissues to such an extent that they do not escape when decompression takes place, and that these small bubbles cause hemorrhages in the minute blood vessels. When these hemorrhages take place in the nerve centers, vertigo, unconsciousness, and paralysis occur. The mildest form of the disease is known as "bends" and affects the joints. The pains are very sharp and last a considerable length of time.

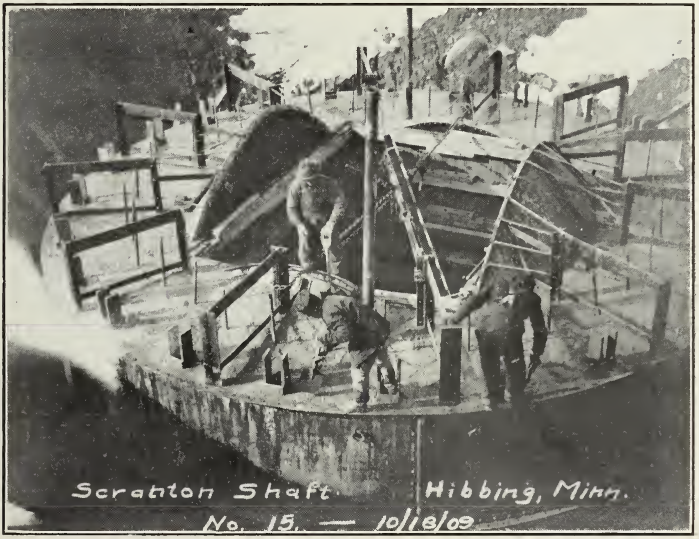


Fig. 4.

Circular Outside and Rectangular Inside Design.
Cutting Edge Partly Filled with Concrete.

Paralysis is the most serious form and generally causes death, but it rarely occurs in pressures lower than thirty pounds. When the expanding air bubbles collect in the lungs, congestion takes place and unconsciousness usually follows. A man may be overcome at any time. No two attacks come under the same physical conditions.

The writer experienced a serious attack of paralysis when he imprudently exposed himself. He went into a pressure of forty-eight pounds twice in the same day, stayed too long for the time he took to decompress, and then exposed himself to a temperature of fifteen degrees below zero upon coming out. No effects were noticed until he had reached his home a half mile distant when sharp pains appeared in the shoulders and gradually worked down into the legs. He at once started for the medical lock but did not get there before he was overcome. After an hour and a half in the lock he was apparently cured but a second attack left him in a condition such that the repeated application of the compressed air had no effect. He has gradually improved since then and now, four years later, has little or no difficulty in walking. The regenerating of nerve tissue and the wasting of scar tissue is a very slow process.

The treatment for all of these diseases is re-immersion in the pressure and slow decompression. The medical air lock is expressly designed for this purpose. It is a large cylinder resembling a boiler, divided into two compartments. The divisions are provided with air supply pipes and steam heat. Special escape valves are placed in both rooms. The man is placed in the cylinder and subjected to the pressure at which he had been working. Unless he has exposed himself to a low pressure too long he obtains immediate relief. Allowing a considerable length of time for saturation, the pressure is then reduced to two-thirds or a half of the original pressure at the rate of about a pound a minute. The remaining pressure is reduced at a much slower rate to allow a slow decompression.

IRON LOSSES AT LOW FLUX DENSITIES

C. J. Huber, '08.

Although much work has been done in investigating the behavior of iron in relatively strong magnetic fields, little is known of its behavior at densities below 500 gausses. The determination of the losses and permeability of iron at such low flux densities has recently become of importance in the commercial world in connection with current transformers, loading coils in telephone work and in various other instruments such as soft iron ammeters and voltmeters. Current transformers are designed to work the iron below the knee of the magnetization curve, giving low losses and high permeability in order that the ratio may be as nearly constant as possible and the phase angle have a small value.

Various methods have been devised to determine the energy loss during the magnetic cycle. The wattmeter method is the one now generally used in determining this loss. A diagram of connection for the simple wattmeter method for measuring the loss at a given voltage is shown in Fig. 1.

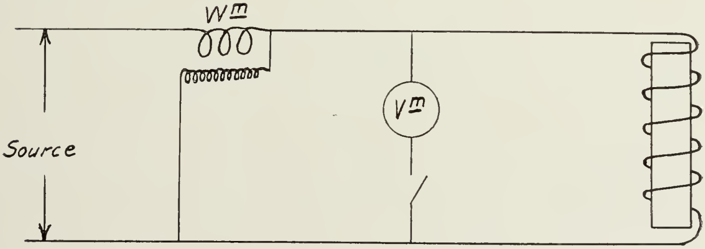


Fig. 1.

The voltage key is left open while the wattmeter is read. Also a correction has to be made for the loss in the potential circuit of the wattmeter. The computation of the results is complicated in this method. It is preferable in any case to have two windings: one for the magnetizing current and the other for the potential circuits of the instruments.

From the very nature of the problem, the voltage must be stepped up in order to obtain the desired sensibility. In doing this great care must be taken to make the leakage flux as small as possible. The entire path of magnetic lines must be completely in the iron or completely outside the iron. This condition is, in practice, best realized with a ring specimen with uniform windings which approaches the ideal case of a current sheet. Butt and lapp joints must be avoided. The flux distribution should be uniform over the cross section and this section be great enough to avoid shearing effects. The magnetic history of the iron plays an important part in measurements of its losses at low densities. Great care has to be taken to completely demagnetize the iron and not to allow the flux to rise above the desired value.

The diagram of connections for the modification of the simple wattmeter method used is shown in Fig. 2. From the dimensions of the core and the number of turns the voltage for a given maximum flux density was calculated. This voltage was measured with a dynamometer with a variable multiplier, which had previously been calibrated on direct current at the exact point used. The alternating current supply was controlled by means of a rheostat in the generator field so that there would be no wave distortion due to series resistance. Two different generators were used, one being star connected 3 phase, thus eliminating the 3rd harmonic and the other, while single phase, gave a remarkably pure wave, so that it was known that the wave used was in either case sinusoidal within 2%. The loss was measured by a second dynamometer, with the exciting current passing through its field coil and with its potential coil with variable multiplier in parallel with the voltmeter. An electrostatic tie was made between the fixed and moving systems to eliminate any electrostatic difficulties that might cause an error in the readings. For the given a. c. voltage the deflection of the wattmeter dynamometer was read and then calibrated on d. c. The product of the d. c. amperes and volts gave the total loss in watts multiplied by the ratio of secondary to primary turns. To obtain the loss in the iron, correction was made for the potential circuits of the wattmeter and voltmeter and the ratio factor removed. The correction, of course, changed for every change of multiplier in either circuit. While taking readings in iron loss measurements the frequency

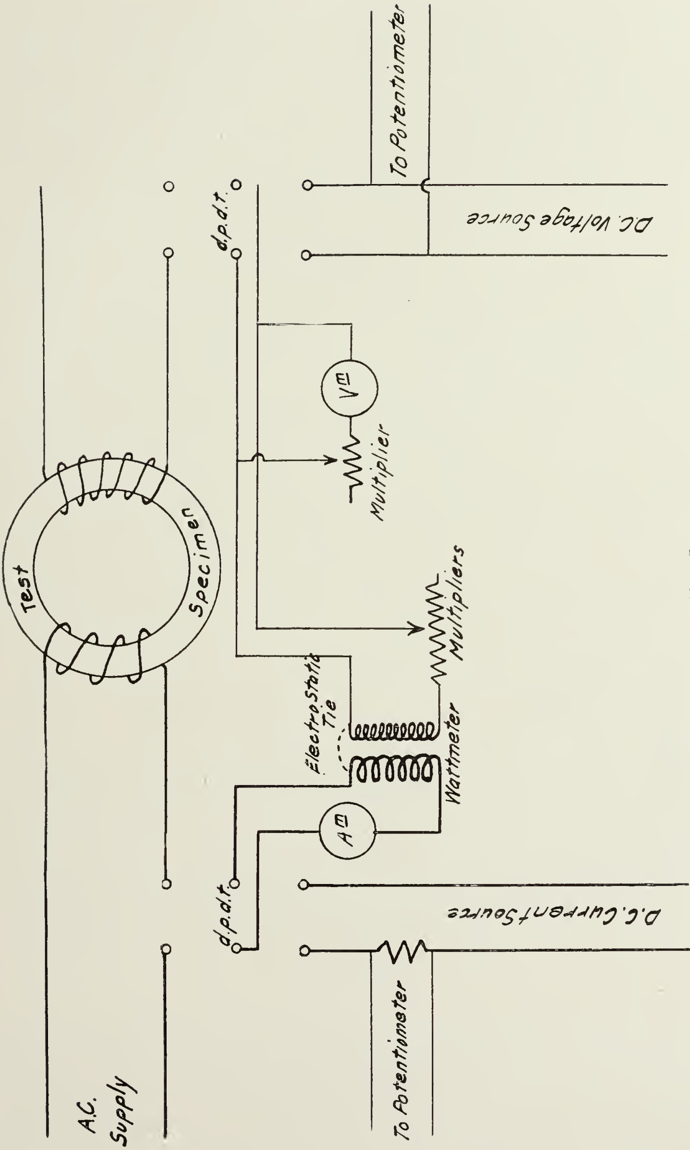

To Potentiometer
D.C. Voltage Source
d.p.d.t.
Vm
Multiplier
Test
Specimen
Multipliers
Electro Static Tie
Wattmeter
Am
d.p.d.t.
D.C. Current Source
To Potentiometer
A.C. Supply

Fig. 2.

must be kept constant. The iron loss by Steinmetz's equation is $W = K_1 \, f \, B_m^{1.6} + K_2 \, f^2 \, B_m^2$ where $f =$ frequency and is seen to enter both terms of the right hand member.

Curve 1, Plate 1, gives the core loss curve for a current transformer, of primary winding capacity of 40 amperes, and ratio of 8 to 1. This curve shows a core loss varying from about .001 watt at 20% full load to .031 watt at full load, giving a good idea of the magnitude of the amount of energy expended in the core of such instruments.

Curve 2, Plate 1, gives core loss curve for a 3 KW, 120 to 4-volt transformer, the core loss being plotted watts per Kg against flux density. This curve very nearly has the form of a parabola, $w = K B^2$, showing that at low densities the loss is approximately proportional to the square of the flux density. From this it may be noted that the Steinmetz exponent, 1.6, for hysteresis loss must approach 2. A current transformer investigated by Agnew[1] gave a ratio curve of the form of No. 1, Fig. 3, instead of the ordinary curve of the form of No. 2.

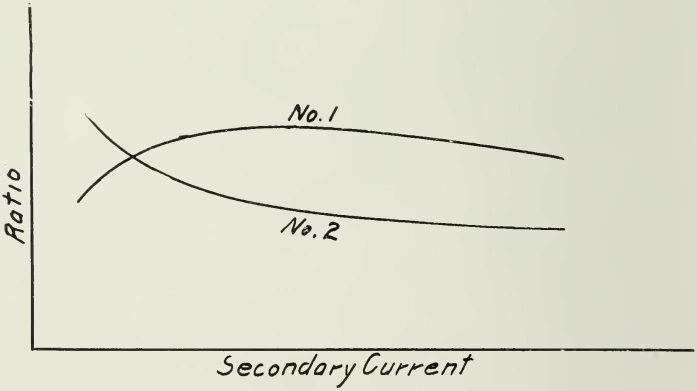


Fig. 3.

From theoretical consideration he has shown that the ratio curve would have the form of No. 1, that is slope downward for low current values, if the ratio of variation $dW/_w : dB/B$ in the core loss equation $W = KB^x$ became

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[1] Agnew.—Bull. Bur. of Standards, Vol. 7, No. 3, Reprint 164.

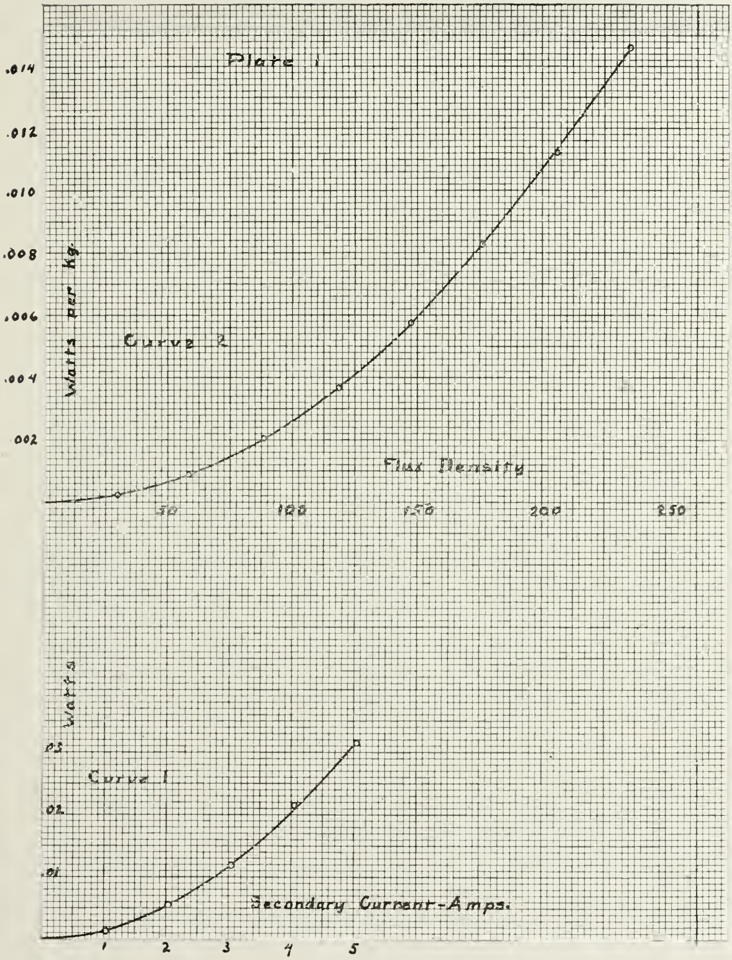


Plate I.

greater than 2 for this part of the curve. Upon investigation this was found to be actually the case.

It has been shown that the usual methods of determining the exponent fail to give the true value whenever the exponent is variable but the quantity which is determined by these methods is in reality the total logarithmic derivative of the iron loss in respect to the flux. For this derivative the name "ratio of variation" has been suggested. However, for the case of constant exponent the ratio of variation and exponent are the same.

TABLE I.

Total Iron Losses (Watts per Kg.)

Flux Density, lines per sq. cm.	Transformer S_1 Ordinary Steel		Transformer S_3 Silicon Steel	
	Cycles			
	30	60	30	60
30	......	.000080	......	.000040
40	......	.000145	......	.000050
50	......	.000235	......	.000092
60	.000158	.000353	.00006	.000135
80	.000294	.000632	.00011	.000256
100	.000458	.000971	.00018	.000390
120	.000666	.00139	.00027	.000570
160	.00116	.00242	.00052	.00103
200	.00179	.00375	.00079	.00167
250	.00272	.00585	.00126	.00270
300	.00385	.00807	.00185	.00385
400	.00653	.0140	.00330	.00694
500	.00895	.0214	.00518	.0109
600	.0140	.0298	.00762	.0154

Table 1, gives the core loss data for transformers S_1 and S_3. The dimensions of their cores and their winding data are the same. This table shows that for a given frequency and flux density the loss in silicon steel is less than one half as great as that in ordinary transformer steel.

The iron loss data have a direct bearing on the design of transformers. For a non-inductive load the formulas[1] for ratio and phase angle are $R = n + \frac{F}{I_2}$ and $\theta = \tan^{-1} \frac{M}{n\, I_2}$ respectively where n is the ratio of turns, M the magnetizing component of the exciting current and F the core loss component of the exciting current.

$$\text{But } R = n\left[1 + \frac{W}{r_2 I_2^2}\right] \text{ since } F = \frac{n\,W}{r_2 I_2}$$

In order to have a horizontal straight line ratio curve it is necessary for the second term of the right hand member to be zero or constant. To cause this term to approach zero, iron with low losses should be used. In order that this term may be approximately constant, W should be proportional to $r_2 I_2^2$. This condition is practically realized when the ratio of variation is nearly constant and equal to 2. Experiments on different kinds of steel with various thickness of sheets would probably result in obtaining a specimen having this ratio of variation. This steel should also have a high permeability so that the phase angle would remain small.

THE RELATION OF THE ENGINEER TO INDUSTRIAL SAFETY.

P. H. Goda, '04.

Every known industry has connected with it a certain element of risk, and although this varies with the industry, in no case is it entirely absent. Many persons are injured each day in industrial accidents. These accidents may be due to a variety of causes, chief among which might be mentioned ignorance, carelessness, unsuitable clothing, insufficient lighting, dirty and obstructed work-places, defects of machinery and structures, and absence of safeguards. Accidents again may be classified as avoidable and unavoidable. Of the avoidable accidents many are directly within the control of the injured themselves and a large per cent could be eliminated by proper supervision and precaution. It is the latter class of accidents which should interest every engineer.

The principles of safeguarding and safeworking in industry should be a part of the education of every engineer. Progress in the elimination of industrial accidents cannot be attained by acts of legislatures, recommendations from casualty insurance companies, and admonitions of sociologists alone, but in a great degree by scientific study of the problems of safeguarding, supervision and instruction of employees. Employer and employees alike must take an active interest in the prevention of accidents to obtain any results from their labors. Mechanical safeguards alone will not prevent accidents, but personal care of the employee is the safeguard which should be chief in every industry, large or small.

Within the past two years many of the railroads and manufacturing concerns have inaugurated safety systems. Primarily, these systems embody the organization of local safety committees representing various branches of service. It is the duty of these safety committees to make periodical inspections of the various departments of the shops and grounds and report unsafe conditions and practices. These reports are made to the superintendent of the shop or division in the case of a railroad, and are accompanied by recommendations to remedy the unsafe conditions. Most of the larger railroads and manufacturing concerns have one or more special safety inspectors who make a special study of the problems of safeguarding and safeworking in the shops. As a result of these precautions safeguards have been applied to all classes of machinery at an expenditure of many thousands of dollars.

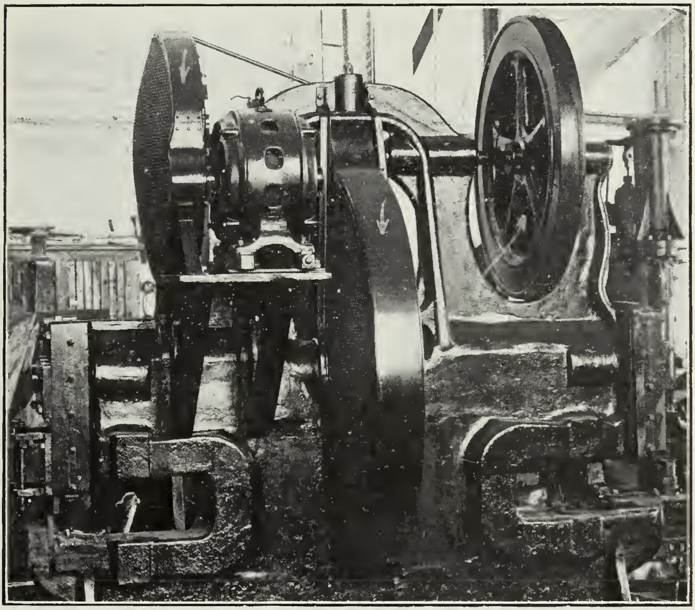


Fig. 1.

Wire Netting and Sheet Metal Guards for Motor Driven Punch and Shear.

There are fundamental reasons why the subject of industrial safeguards should be of the greatest interest to an engineer. The installation of safety devices in a new plant, the proper equipment of new machinery that may be added to it from time to time and the application of safety devices to old equipment involve the expenditure of large sums of money and the problem of the economical expenditure of this money is primarily one for the engineer. In laying out new work the engineer can provide safeguards with minimum trouble and expense eliminating a difficulty of providing satisfactory safety devices at a great expense after the equipment has been constructed and placed in service. In many drafting rooms drawings are now checked for safety before they are accepted to make sure that all desirable safety features have been included in them.

The standardization of safety devices is an important feature of the safety work. Some of the larger corporations have compiled standard specifications and safety rules for engines, boilers, electric cranes, elevators, machine tools, etc. It is the practice of nearly all machine tool builders now to provide machines with ample safeguards, particularly to cover all gears. Sometimes these guards are rather incomplete, showing that the designer had in mind appearance rather than utility. A discussion of the specifications for various safeguards is given below. These specifications represent data for safety requirements of equipment now used in the shops of many large and progressive corporations.

GEARS.—All gears should be completely enclosed not only at the meshing point, but around the entire circumference. The sides of the guard should be flanged to cover the teeth to the base. Many gear guards which are applied by manufacturers of machines cover only the outside of the gears leaving an opening between the guard and the teeth which makes a trap for injury in place of a safeguard. Gear guards should not be removed from a machine. Where gears must be changed such as feed gears of lathes, the guard should be so attached to the machine that it can be opened or lifted by means of hinges. A removable guard is not safe, as a workman being accustomed to a guard may remove it and forget to replace it and injury result when gears are exposed. Large gears should have the arms covered either by making a solid cover of sheet metal or a center of wire netting and cover over teeth of sheet metal. The combination guard of sheet metal and netting has the advantage of affording a view of the gears for inspection of any possible defects.

SET SCREWS.—Set screws with heads projecting above surface should not be used in shafting or revolving parts of machinery of any description. Either a hollow set screw should be used or the projecting head countersunk below the surface, using a socket wrench for adjustment. On old equipment when the stock is not heavy enough, it is sometimes necessary to apply collars so that head of screw can be countersunk. Projecting head set screws are sometimes covered with rubber or leather or even wooden disks, the halves being held together by wire. The safest plan, however, is to keep the heads below the surface or use hollow set screws.

BELTS AND PULLEYS.—Belts supplying power from the main shaft to the machines should be guarded where they pass around pulleys close to the floor to prevent danger of workmen being caught between the belt and the pulley. Large high speed belts under which workmen may be employed should have sheet metal or wood shields underneath them to prevent injury in case belt breaks. Pulleys located near the floor should have the arms covered with sheet metal plates fastened to them by means of U bolts.

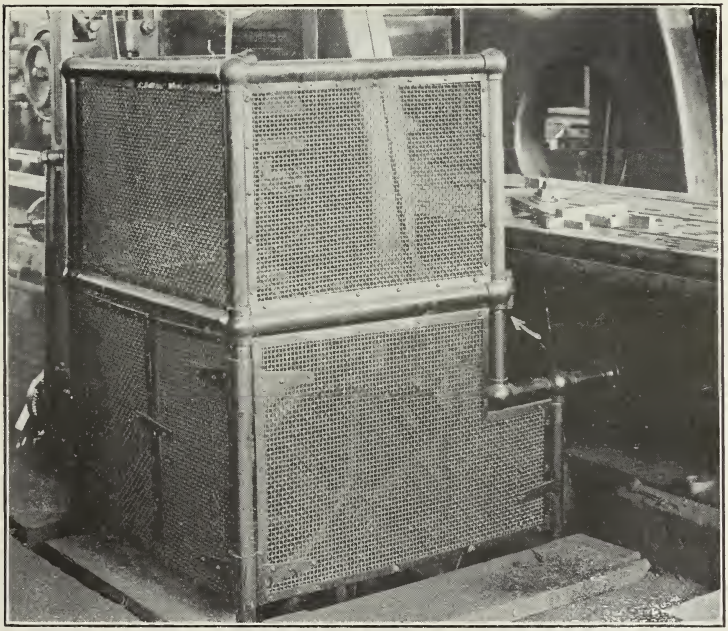


Fig. 2.

Wire Netting Guard for Planer.

Belt shifters should be provided for throwing belt back and forth from tight to loose pulleys, and be equipped with a locking arrangement so that they will not allow a belt to creep from the loose to the tight pulley and allow a machine to start up when the operator is not expecting it.

EMERY WHEELS.—Emery wheels should be provided with strong hood guards to hold the fragments in case the wheel bursts. When these guards cannot be used the safety collar having one side concave to grip the wheel should be applied. The rests should be kept close to the wheel, in good order, and set at the proper height. Many accidents on emery wheels are due to fingers being caught and ground off. Plate glass guards should be applied to the hood over the exposed part of the wheel to protect the eyes of the workman from flying particles of emery and metal.

Emery wheels which are used for heavy grinding and polishing should be provided with dust collectors connected to an exhaust fan to carry off the dust.

SHAFTING, OILING RUNWAYS, LADDERS, WALKS.—Individual motor drives are far superior to a network of overhead shafting and belts, eliminating various sources of danger and improving the lighting conditions. Shaft couplings having exposed bolt heads and nuts should be covered with metal sleeves and projecting head set screws should not be used in collars.

Overhead shafting must be lubricated and it is, therefore, necessary to provide convenient oiling runways so that the oiler can do his work without hazard. Permanent iron ladders should be so placed that these runways can be reached conveniently from various points in the shop.

Portable ladders should be fitted with spurs of iron or basswood or safety feet having a carborundum surfaced metal plate to render them non-slipping.

Permanent walks should be provided around boilers to reach water columns and operate valves in steam lines.

METAL PLANERS.—Open spaces in planer bed plates should be covered with sheet metal aprons. Workmen often store clamps and bolts in these open spaces and sometimes have their arms caught between the moving bed and the plate.

SAWS.—Band saws should have upper and lower wheels boxed in, preferably with wood doors so as not to damage the saw in case it breaks. An adjustable guard should be placed in front of the exposed edge of the saw to prevent injury, in case the operator should slip and fall or get his head too close to the saw.

Circular saws should be provided with adjustable hoods, and spreaders to spread the material, preventing the "kick-back" which has caused many injuries.

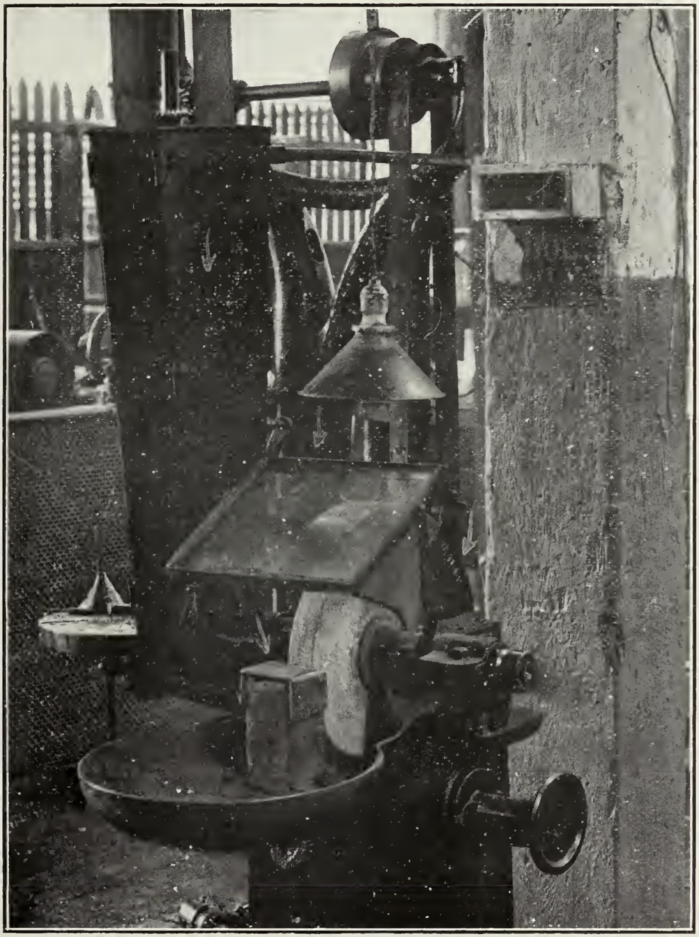


Fig. 3.

Metal Hood, Glass Shield and Belt Guard for Emery Wheel.

Swing saws should have a guard in front of the teeth to keep the operator's hands from coming in contact with them.

WOOD SHAPERS AND JOINTERS.—The wood shaper is a dangerous machine and should be provided with guards to prevent fingers slipping into the cutter head.

Jointers should be equipped with safety circular knife heads and automatic guards to cover the revolving head. The guard is pushed to one side as material passes through and automatically covers the head again.

ELECTRICAL APPARATUS.—Rubber mats should be provided both in front and back of switchboards, also around transformers and commutator end of generators.

The backs of switchboards should be enclosed and kept locked except for purposes of alterations or repairs.

Switches should be tagged when opened for repairs on a line. The person making repairs should place the sign and it should not be removed until the operator is notified by the person that the work is done. In some plants locks are provided for switches, the key being taken by the repairman working on the circuit.

The frames and bed plates of all generating machines, motors, transformer boxes, ladders and other metallic parts should be jointly and efficiently grounded.

Motor starting rheostats near floors should be screened or boxed.

Wiring should be placed in conduit which should be continuous to switch boxes and rheostats so that there are no bare terminals or live conductors exposed.

POSITION OF MACHINERY.—The installation of machinery in relation to walls, passages and adjacent tools and equipment should receive careful consideration. There should be a clearance of not less than 18″ between the extreme position of the reciprocating parts of any machine and the wall or other fixed structure.

STATIONARY EQUIPMENT.—Open stairs, gangways, open vats, tanks or pans should be provided with double pipe railing, at least 36″ high and if necessary provided with panels of wire netting.

TOOLS.—The handles in hammers and sledges should be kept in good condition. The heads of drift pins, chisels. bars and like tools should be kept free from burrs to eliminate eye injuries.

In concluding this brief review of the more important industrial safeguards some mention should also be made of the administrative measures.

Durability and Maintenance of Safeguards.—Safeguards should be constructed of metal and in the case of old equipment preferably of sheet steel or iron, and wire netting. Netting is superior to solid metal since it permits of easy inspection without removing the safeguards and does not interfere with lighting conditions.

Safeguards should be maintained in position by workmen and neglect on their part to do this should be brought to their attention.

Warning and Caution Notices.—These should be brief and used sparingly. Long rules are not effective and are worthless if no attempt is made to enforce them. Workmen become so accustomed to the sight of a great many notices that their effect is soon lost. The admonitions of a careful foreman will have more effect on a workman than a whole catalogue of rules.

First Aid.—It is the practice in most of the large industries to give immediate and competent first aid service within the plant. The prompt cleaning and dressing of slight accidental wounds gives relief to the injured and renders later medical attention more effective. Trivial injuries may result in serious consequences, if neglected and not treated at the proper time.

Every engineer should practice safety engineering to the best of his ability, without regard to compulsion or legal minimum and should co-operate with his associates in bringing about an improvement in the conditions of industrial life, and a reduction in industrial accidents.

THE MANUFACTURE OF RESISTANCE WIRES.

E. W. GENT, '08.

In order to meet the exacting requirements of the present day demands for resistance wires, it is necessary that none but the purest of metals be used. These alloys are made up in small batches and with the utmost care to prevent contamination. After the metals have been properly alloyed they are cast into ingots and successively reduced in most cases by hot rolling to ¼" diameter rods and from this stage are reduced by cold drawing through "steel plates" or "diamond dies."

Aside from the German Silver alloys which are Nickel-Copper-Zinc alloys, resistance alloys are either, Nickel-Copper, Nickel-Steel or Nickel-Chromium. A few words concerning the particular field of each, together with their chief characteristics might be well before describing the various operations of manufacturing the same into wire.

The Nickel-Copper alloys usually containing approximately 40% Nickel, have a resistance of about 300 ohms per circular Mil foot, and a resistivity co-efficient which is practically zero, changing from a "plus" value for hard drawn wire to a "negative" value when the same wire has been annealed. They usually have a Thermo E. M. F. against copper of 38 Micro-volts per degree Centigrade which is very high and because of this it is largely used in Thermo couples with either Copper or Iron.

Nickel-Steels are either the 2% or the 30% Nickel mixture. The latter has a resistance per mil foot of 525 ohms and because of this high specific resistance together with its low cost is largely used in rheostats carrying heavy current.

Nickel-Chromium alloys have the highest specific resistance, it being about 600 ohms per mil foot, and a medium resistivity co-efficient depending upon the gauge, temper, and operating temperature. These alloys are used almost entirely in electrically heated devices as they will withstand red heat indefinitely without appreciable change in structure.

ANNEALING.

The rods as they come from the rolls have not the same temper throughout and it is necessary to anneal them evenly before "drawing." The annealing operation is accomplished by either "open annealing" in a muffle or "pot annealing." In the latter method the rod or wire is put into large iron pots and sealed with either charcoal or iron borings. The purpose of the charcoal or borings is to take up the oxygen from the air within the pot and prevent the wire or rods from oxidizing, and also to prevent furnace gases from entering the pot. These pots are trucked into the annealing oven and brought to a heat approximately 1600 degrees F. and after the pot has reached the furnace heat it is left to "soak" for sufficient time to permit complete adjustment of molecules. After removing the pot from the furnace it is left to cool 12 hours before the wires or rods are removed.

CLEANING.

Any oxide or other surface coat must be removed from the wire and rods before attempting to "draw" them and this is accomplished by "pickling" in vats containing suitable acids. After the wire is thoroughly clean it is washed and dipped into a lime water bath which neutralizes any trace of acid and when baked on the wire forms a protective coat essential to the proper lubrication of the wire when being "drawn" through the "draw plates."

DRAWING.

The lime coat above referred to together with a lubricant is not always a sufficient coating and some very abrasive alloys require a coating of a flour paste baked on the surface to prevent the wire from "tearing" out the hole in the "draw plate."

The rod or wire is reduced in area by successively drawing or pulling the same through a hole in a steel plate, the construction of which is as shown in the accompanying figure. The portion along A is a frustrum of a cone and it is along a portion of this surface that the wire entering with diameter A″ is reduced by force F to diameter A′. The portion B of hole is the "sizing portion" and is cylindrical in shape. After the wire has been successively drawn through several holes it becomes very hard and it is necessary to anneal as described above, after which it is again cleaned, limed, baked and drawn again.

The wire is pulled or drawn through the holes by means of revolving blocks which are conical drums and about which the wire is coiled. The wire is drawn through either tallow, powdered soap, or other suitable material before passing through the steel "draw plates" and by means of this material the wire is prevented from coming into direct contact with the steel surface within the hole.

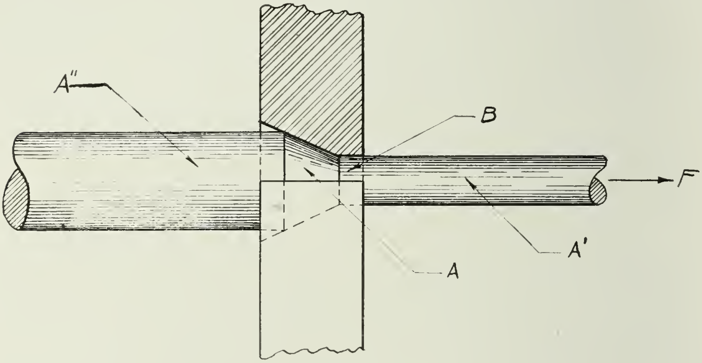


Fig. 1.

After the wire has been drawn to .040" in diameter it is drawn through wet solutions of soap and tallow then through diamonds imbedded in steel casings through which the hole has been drilled having proper shape and size.

These are the essential operations peculiar to the manufacture of resistance wire and inasmuch as there is allowed only a 5% variation in the resistance per foot of the finished wire, it is apparent that the greatest care should be taken in the various operations as the resistance varies with the mixture, annealing, temperature, time, and distribution of work during the drawing process.

CONCRETE AS A MATERIAL FOR CONSTRUCTING CITY PAVEMENTS AND COUNTRY ROADS

C. D. Franks, '11.

For years engineers and others have been looking for a road building material which would satisfactorily meet the requirements of prevailing conditions, and close observation of concrete roads and pavements points to the success of this particular class of construction. The particular advantages of concrete are: comparatively low first cost; low maintenance charge; freedom from dirt; comparative noiselessness; ease of traction for vehicles; small crown necessary to get rid of surface water; simplicity of construction; and ability to successfully resist the wear and tear of traffic.

In general, at the present time we find four types of concrete roads or pavements in use throughout the country besides two or three patented types of construction, which will not be considered here. By far the greater number of concrete roads and pavements are of the common type of construction, known as the two-course and the one-course pavement. The former class consists of an ordinary concrete base covered with specially prepared and independently laid cement mortar, or concrete wearing surface. The one-course pavement is composed throughout its entire thickness of a concrete of the same mixture or quality laid in one operation, and the choice between the single course and two-course road should be governed by the material available for the work. Hard stone, such as granite and trap rock, make the best wearing surface for concrete pavements. As a rule such stone is more expensive than gravel, but the cost of construction can be reduced by using this more expensive stone in the wearing surface only. Where but one grade of material is to be had, for example, sand and gravel, single course work is to be recommended. Such a pavement will be as durable as two-course work of the same material, and in addition can be laid cheaper. Another type which follows the two just mentioned is the reenforced type. While the additional cost is small, the efficiency of the street is greatly increased, there being no surface cracks formed, due to uneven settlement or heaving.

Another type which might well be mentioned before going into the details of construction and one which seems to have gained some foot-hold, especially for residence streets in smaller cities, is the single course pavement with the application of bitumen and sand. The pavement as originally built, consists of two courses. The first, a 4½-inch layer, mixed 1:2½:5, and the second a 1½-inch wearing surface, mixed 1 part cement to 2 parts clean sand. Transverse expansion joints were left every 25 feet, and half of the street was laid at a time. On top of the concrete so placed, about one-half gallon per sq. yd. of hot tar was applied and after being spread over the surface with a street sweeper, pea-gravel was sprinkled over the whole and the traffic turned on the pavement. Regardless of the material used in this top it will be necessary to have a good concrete base, for if no maintenance department is at hand it is impossible to expect this top to last longer than two years under average traffic, and the concrete must be of such a character that it will withstand the traffic until such time as the top can be renewed. While this wearing surface may not last over two years, still it makes a satisfactory and effective covering especially suitable for residence streets in small cities.

In discussing the various operations of construction the same may be applied in nearly every case to either one-course or two-course work. After deciding upon the type of concrete pavement, the work of construction begins. It is usually the custom to do the work either by contract, or under the direct supervision of the engineer in charge. The character and experience of the contractor bidding on the work would determine which method is the most advantageous. Drainage is the first point to be considered in the laying out of the road or pavement construction. In a flat country, it will first be necessary in certain parts of the road to create artificial drainage. This may be accomplished by varying the depth of the side ditches, or by means of a sub-base and a system of open ditches on drain tile connected with the sewer or other suitable outlets. In all cases the elevation of high water for any considerable length of time should be at least 1 ft. below the top of the sub-grade of the road, in order that the foundation may not be affected. The sub-grade of the foundation, after it has been approximately graded to profile by means of road graders, plows, or scrapers, should be thoroughly compacted with a roller weighing approximately 10 to 15 tons. The soft places should be excavated and refilled with some material which will give satisfactory results. After the sub-grade has been prepared, it is of the utmost importance that it be kept hard until the concrete is in place. Teams hauling materials must be kept off of the finished sub-grade, and it will be found advantageous to dump the materials outside the line of the forms or curbs. The roller should go over the sub-grade within 24 hours of the time of placing the concrete, in order to make certain that it is satisfactory. The crown of the pavement which is slight in comparison with other standard types, may be partially obtained by crowning the sub-grade, giving it a rise at the center of approximately 1/100 the width of the road. If the foundation requires a sub-grade in order to properly support the pavement the layer of materials used should be not less than 6 inches in thickness, and not less than 6 inches below the finished surface of the pavement. Where a heavy, wet soil is encountered, a sub-base of suitable material, such as cinders, gravel or small stone, should be used.

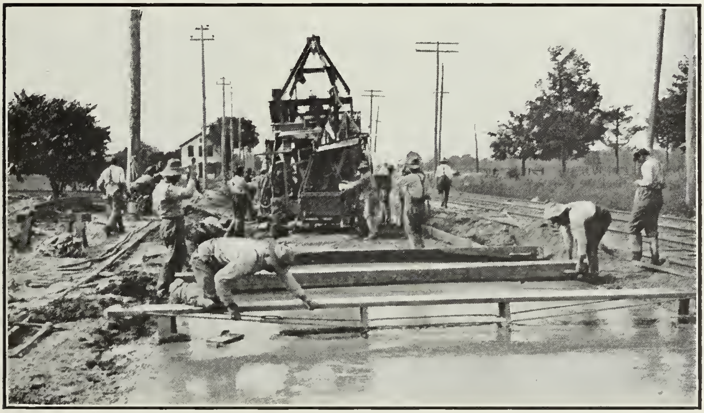


Fig. 1.

The fine aggregate in the concrete should in every case consist of sand, crushed stone, or gravel screenings, graded from fine to coarse, and passing when dry a ¼-inch screen. Preference should always be given to silicious materials, which are clean, coarse, free from dust, and soft, such as loam or other deleterious matter. It is always advisable, when possible, for the engineer in charge to submit the material to test in construction work of this character. The aggregate for use in a mortar wearing coat for the two-course work should be selected from close grained rock or stone screenings. These materials should always be given preference over the sand, as results show in recent years that such materials will produce a surface which will wear much better than a mixture of sand and cement. The writer finds a very satisfactory mixture for the wearing surface to be one composed of 40 per cent cement, 50 per cent granite, and 10 per cent sand. Three-fifths of the granite being ¼-inch to ½-inch, and two-fifths of ¼-inch screenings.

The coarse aggregate for the concrete should be of first class quality, uniformly graded from ¼-inch to 1½-inch, consisting of crushed stone or gravel of good durable quality, gravel giving in nearly every instance the best wear. Considerable question has been raised as to the use of a naturally mixed aggregate in building concrete pavements; that is, the material as it comes from the pit or river. In nearly every case the ratio of the percentage of sand to the percentage of gravel is variable, so that the expense of screening and reproportioning is certainly justifiable, because of the better results and a more uniform mixture of concrete being obtained. On a prepared sub-grade a good form must be placed if the pavement is to be laid without curb or gutter. These forms should be held firmly in place by means of stakes, both to line and to grade. The forms most commonly used are, 2 by 6-inch planks, 12 ft. long. These forms should be clean, and wetted down with water before the concrete is put into position.

From time to time several important changes in regard to thickness and mixtures used have been made, which have materially increased the efficiency of the concrete pavement. The one-course work has been adopted as standard. The thickness of the one-course pavement should never be less than 7 inches at the center, made of a 1:2:3 mixture. In the two-course work, a 6-inch base of a 1:2½:5 mixture, finished with a 1½ to 2-inch wearing coat of 1:1½ mixture, is generally acceptable. In every case the wearing surface is put on immediately after the base is in place. This allows for a good bond between the two courses.

Before placing the concrete, the sub-grade should be moistened. This is necessary to avoid the danger of the earth drawing moisture from the concrete. This wetting should not be sufficient however, to make the sub-grade muddy. The concrete should always, if possible, be mixed in a batch mixer. It is important to obtain uniform mixing throughout the mass, and with a continuous mixer, the only way of an inspector knowing the amount of cement going into the work, is to count the sacks and measure the work placed during the day. This is very unsatisfactory as the pavement does not, as a rule, run uniform in thickness. There are in use today a large number of batch mixers, especially designed for road work.

It will be found advantageous to mix the concrete to such a consistency that the mortar can be flushed to the surface readily, thus making finishing easy. In depositing the concrete, it is necessary to make sure that there is no separation of the particles, and men back of the mixer should be trained to look after the larger stones and rack them to the bottom, thus giving the road a uniform surface. Differences of opinions are in evidence in regard to the finishing of the surface of the concrete in order to afford a good foot-hold for horses. In some places corrugations have been tried. However, in late years a large amount of work has been laid with smooth surfaces. Immediately after the concrete is in place it is struck off and slightly tamped by means of a heavy wooden template, cut to con-

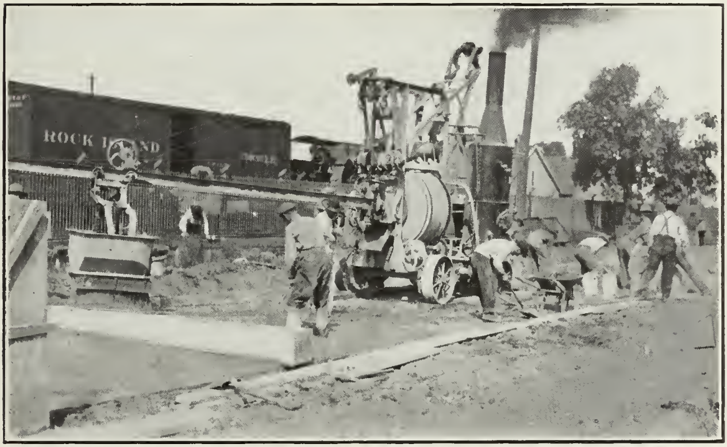


Fig. 2.

form to the ground of the finished pavement. The template is supported on the side forms or the gutter, and if the road is not too wide can be moved along by men at each end. Striking the surface of the concrete in this way has a tendency to force the larger particles of stone or gravel into the concrete and bring the mortar to the top. Men supplied with ordinary wooden floats, then float the surface, and in this condition it is left for travel. In some cases, however, the concrete surfaces are broomed with an ordinary street broom; this operation being carried on while the concrete is still green.

During the summer months and during the time when there is danger from frost, it is advisable to protect the concrete against the elements. The morning following the day in which it is placed, the concrete should be covered with about 1½ inches of earth, which is kept moist for a period of several days. Traffic should not be allowed on the concrete for at least two weeks after the surface is completed.

It is admitted by all, that expansion and contraction in concrete pavements, due to temperature changes must be provided for. At the present time, it is good practice to place expansion joints every 25 feet running perpendicular to the axis of the street. These joints are usually ⅜ inches wide, filled with either some asphaltic filler, suitable for the purpose, or asphalt, felt, or tar paper. When the pavement is bounded by a curb and gutter ½-inch joints are left running parallel to the axis of the street, along each side separating the pavement from the curb and gutter. The width of this joint depends to a certain extent upon the width of the pavement, but is as a rule, ½ inches to ¾ inches wide.

The tendency today is to increase the number and decrease the width of the expansion joints, and since these joints have a slight tendency to spall under traffic, even though rounded to a ⅜-inch radius, it is the custom to use protector plates, placed on each side of the joint embedded in the concrete. The most satisfactory protector is a ¼-inch plate of soft steel, 3 inches wide and provided with fins punched from the center of the plate. These fins embedded in the concrete hold the plates securely in place with the upper edge at the same level as the finished surface of the pavement.

It has been the experience of the writer that pavements wider than 20 feet should have a slight amount of reinforcing. This reinforcing has been very effective where tried, in preventing pavements from cracking. Metal can be used successfully in both the one-course work and the two-course work. During the past two years reinforced concrete pavements have been laid at Fond du Lac, Plymouth and Sheboygan, Wis., Connersville, Ind., as well as several other places. The metal used in reinforcing these pavements was the triangular mesh woven wire reinforcement, manufactured by the American Steel & Wire Company, Style No. 7. This reinforcing fabric can be obtained in varying widths and is cut in strips of the required length. These strips are laid upon and slightly pressed into the concrete base as soon as it is laid and immediately after the wearing surface is deposited and finished. In all cases the heavier wires run perpendicular to the axis of the street, each layer overlapping the preceding one at least 2 inches. Another case of reinforcing was used in one instance at Detroit, Mich., where the pavement is reinforced with ⅜-inch bars, placed perpendicular and parallel to the street, 2 ft. centers and 1½ inches from the surface of the concrete. In addition ¼-inch bars were placed directly beneath the ⅜-inch bars, 4 feet apart and 5 inches from the surface of the concrete. This system of bars is well clamped together and held in place by steel fasteners.

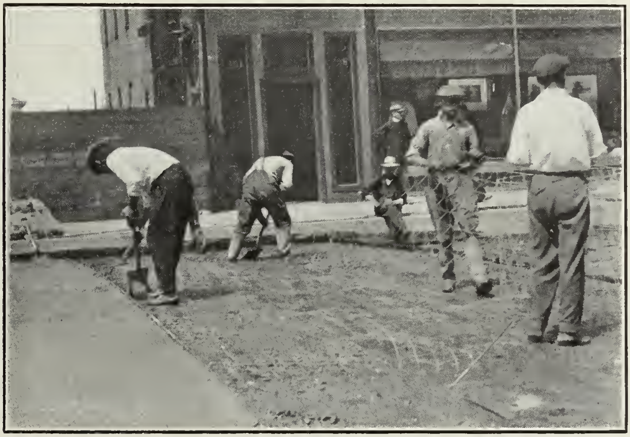


Fig. 3.

Reinforcing with Woven Wire.

The cost of construction will, of course, depend upon local conditions, the cost of material and labor, and to some extent upon the details of construction. However, in the construction of concrete pavements a comparatively cheap, but satisfactory material and one that costs much less to lay is substituted for the expensive brick or block wearing surface, which explains in a word why such a pavement can be constructed at a much lower cost than those now in general use. A properly constructed concrete pavement meets the demand today for a permanent pavement approximating in first cost the ordinary macadam road and in durability the better types of street pavement.

Today, Fond du Lac has about eight and one-half miles of concrete pavement on its principal streets which has been laid by contract, according to specifications prepared by the city engineer. In 1908, the contract price varied from $1.24 to $1.37 per square yard on streets 27 to 32 feet in width. In 1909, the price varied from $1.10 to $1.32 per square yard on streets 27 to 50 feet in width. In 1910, reinforced concrete pavement was laid at a cost of $1.20 to $1.27 per square yard, while the pavement laid that year without reinforcing cost $1.09 per square yard. During the past year the contract price for reinforced concrete pavement was $1.25 per square yard. With combination curb and gutter at 46 cents per lineal foot, this makes a total assessment of but $2.31 per foot on streets 30 feet wide, a low cost for first-class pavement. During the past two years the average price of materials per cubic yard, f. o. b. cars Fond du Lac, was about as follows: Sand and granite for the wearing surface, $1.20 and $2.75, respectively; crushed stone, 92 cents; gravel, about $1.00 per cubic yard on street; and cement, $1.25 to $1.35 per barrel.

The concrete roads in Wayne County have cost from about $1.10 to $1.80 per square yard, the variations depending largely upon the cost of grading and drainage and the length of haul for materials. During 1911 on one road, approximately 3¼ miles of 16-foot pavement with a 4-foot gravel shoulder on each side, was laid at a cost of $1.35 per square yard for pavement proper. The cost of open ditches, tile drain and three small reinforced concrete culverts, proportioned over concrete yardage, amounted to $0.0758 per square yard, making the total cost for 16-foot roadway approximately $1.426 per square yard, or approximately $13,400.00 per mile for a 24-foot roadway. The cost of gravel shoulders is proportioned over concrete yardage and is included in the cost per square yard. Cement for this particular work costs about \$1.05 per barrel, wash sand and screened wash gravel about \$0.83 and \$1.00, respectively, per ton f. o. b. cars on the nearest siding. Common labor costs 22½ cents per hour.

A concrete pavement is easily and economically cleaned and repaired and from a sanitary and aesthetic point of view, is an ideal pavement. Where properly laid, such a pavement affords a good foot-hold for horses; its resistance to traction is probably less than for any other type of pavement, and while it is not as noiseless as asphalt or wood block, unless covered with bitumen and sand, it is superior to brick and stone block in this respect. Such pavements are probably not adapted to the heaviest traffic of our large cities, but may be considered as suitable for paving residence streets, alleys, courts and squares, county roads and highways.

ENGINE INDICATOR ERRORS.

R. G. Brown, '03.

Engineers have always recognized the presence of errors in indicator diagrams produced by the inability of the drum spring to coil and uncoil with the same tension, and the attendant stretching of the cord between the reducing motion and the indicator. It is also well known that the errors increase with increased speed of reciprocation. The most careful engineers, therefore, endeavor to prevent these errors as far as possible by using short and straight leads to the reducing motion and by having each member as rigid as possible.

It was the effort to find some way to measure this error present in revolving the drum that lead to the designing of the mechanism illustrated and the carrying out of several experiments. The mechanism is believed to be different from others which will be found described in Mechanical Engineering Laboratory Manuals in that it produces a diagram which shows the actual error measured in inches under the conditions of operation.

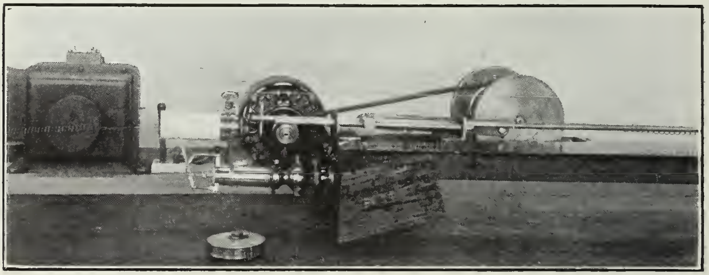


Fig. 1.
Experimental Apparatus.

The illustrations show that the indicator is mounted on a heavy framework of wood by means of a regular indicator cock, screwed into a flange. On top of the frame is arranged a small crank and connecting rod mechanism for the purpose of reciprocating a long steel rod. The drum of the indicator must be lined up to be parallel with this rod.

One end of this rod moves the indicator pencil and to the other end is fastened the indicator cord, which makes one right angled turn around the guide pulley of the indicator. A fine steel wire connects the pencil to the rod; another wire and spring keep it taut. This provides a good means of applying the pencil to the diagram paper at just the right moment. The indicator spring must be left out and all parts in good condition and well oiled.

The principle involved in the operation of this mechanism is as follows: The pencil and drum being driven at the same speed, the latter about its horizontal axis while the former moves parallel to that axis, the resultant diagram should be a 45 degree line.

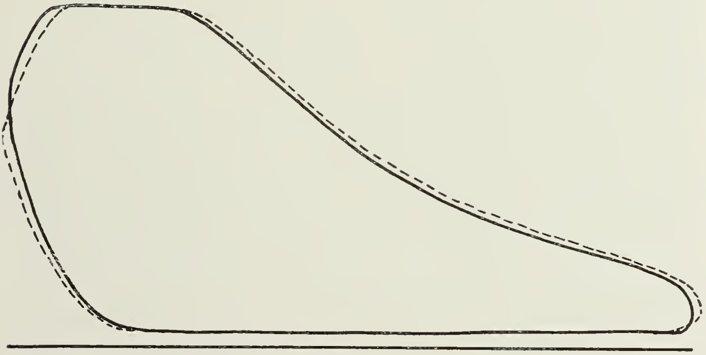


Fig. 2.

Distortion of Indicator Card at Moderate Speed.
Solid Line Shows Card as Taken, Broken Line Shows True Shape.

But even when the mechanism is revolved slowly by hand a diagram is drawn enclosing an appreciable area. The horizontal distance on this is a measure of the error present when the indicator is used under the corresponding conditions and speed. When diagrams are taken at different speeds, the shape and size change in proportion. The error accumulates from inertia effect, the stretching of the cord, small amounts of friction in various parts, and some deflection of each member.

Different indicators will, of course, give entirely different diagrams, but they will always increase in size with speed. The indicator used was of good make and in best condition. When desired, the mechanism can be arranged to run the indicator under service conditions, thus obtaining diagrams which will aid in correcting the volume lines of the indicator card.

As a rule, this error of drum action causes the indicator card to be smaller in area than it should be, the percentage effect being much greater on light load cards and gas engine cards. The shape of the cards, especially at the ends of the stroke, may be much distorted without the operator being aware of it.

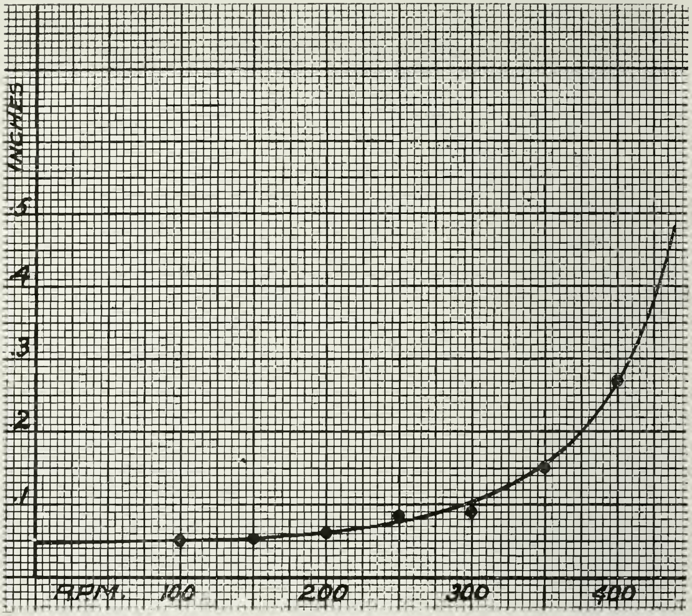


Fig. 3.

Relation of Speed and Mean Error of Drawn Motion.

It is proper to conclude that too much care cannot be taken in the manner of using and setting an indicator. A correct and well adjusted reducing motion is presupposed and a direct, short and unstretchable lead cord should be used. All turns should, if possible, be eliminated and the indicator mounted rigidly. If there is the slightest wobbling or lashing of the cord there will be much error in the cards taken.

Some diagrams taken with the mechanism described are given below and are representative of a good many sets. The error was practically constant below 200 revolutions per minute and we are fairly safe in deciding from the shape of the diagrams that no inertia was present. The tension of the drum spring was constant for the diagrams illustrated, and a standard make of indicator cord 3½ feet long was used. The area of each diagram was carefully measured with a planimeter. This value divided by the height gave the mean horizontal error in inches.

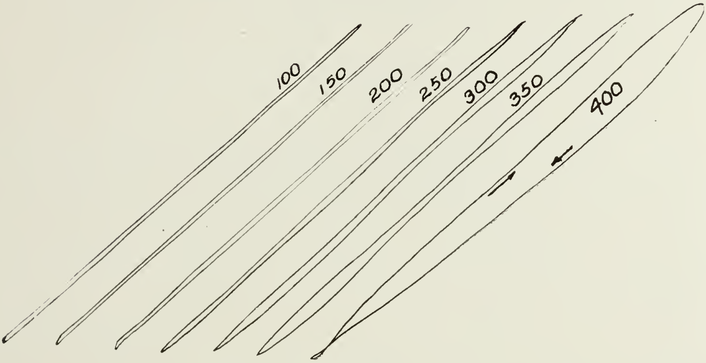


Fig. 4.
Diagrams Taken at Speeds Marked.

R. P. M.	Average Horizontal Error in Inches.
100	.05
150	.055
200	.06
250	.085
300	.09
350	.15
400	.27
450	.68

The curve given above is plotted from this table.

MODERN RAILWAY MOTOR CONTROL EQUIPMENT

A. B. Cole, '09

Electric railway control is divided into two general forms, namely, the drum or "K" type, and multiple unit control; the first being for single car operation, while the latter is for either single car or train operation. The following remarks will be confined to the railway control applicable to single car or train operation, that is, Unit Switch Control.

As the railway motor rapidly advanced, it became possible to build high powered motors, and these required reliable, simple, and effective control apparatus, which could handle the heavy currents incident to operation of such motors. Above all, in order to handle these heavy currents, it was necessary to have contacts held together under high pressure, and effective circuit breaking apparatus that would extinguish the heavy arcs that are made when opening circuits under load. The power necessary to effect the making and breaking of circuits mentioned above could not be entirely dependent upon the trolley current.

Compressed air with its unparalleled record of reliability in the air-brake, switch and signal fields was chosen as the auxiliary agent for power, and since nearly all electric cars are now supplied with air brakes, the utilization of compressed air in connection with electric railway control apparatus was the obvious result. The use of compressed air in closing, and of a heavy spring in opening contacts that carry heavy electric currents, secures many advantages not possible by any other means, such as high pressure between contacts regardless of the trolley voltage, and a substantial reduction in the wearing away of metal and welding together of contacts due to arcs drawn by slow opening of switches. Also, since the contact pressure is very positive, the contacts have a high carrying capacity and may be narrow, thus permitting effective magnetic blow-out action to take place at the switches when opening, since the air-gap between blow-out coils is a minimum.

Unit Switch Control equipments are used on roads operating at 500, 600, 1,200 or 1,500 volts direct-current, and on single-phase alternating current. It presents a number of advantages over the platform type of control even when used for single car or locomotive operation, such as—

1. Switches and contacts are assembled in one compartment, with all heavy current carrying parts located beneath the car. Circuit breaker action takes place beneath the car and is not visible to the passengers.
2. Each circuit breaking switch or contact is arranged in an isolated asbestos or vulcabeston insulated section, and is provided with a powerful blow-out more effective than that on the average circuit breaker. A short-circuit is opened by two or more switches in series, the duty of handling heavy currents not being imposed on any one switch.
3. A very low current is used in the master controller so that all former platform controller burn-outs are eliminated.
4. The controller occupies but very small space on the car platform.
5. There is approximately 100 pounds or more pressure between each pair of the heavy current carrying contacts. Heavy cylinder springs insure the positive opening of switches.
6. Less wire is required for motor circuits. All motor current wires are located beneath the car and are thoroughly protected against the danger of fire.
7. The apparatus is designed on the unit principle so that all parts may be readily inspected and easily replaced. The arrangement of the moving parts is such that a wiping action of the contact tips is obtained, so efficient in its operation that long life of the contact tips may be obtained with no attention in the way of filing and trimming. The equipment is so arranged that the car-barn men can easily maintain it. It has the working parts accessible and as few as possible, and wearing of the working parts does not affect the efficiency or reliability of operation.

During the first few years of operation a prejudice existed against the pneumatic control on account of the belief that the pneumatic parts would collect moisture and freeze during the winter. It has been demonstrated during several severe winter seasons in northern cities that the question of freezing is negligible if the cars have the reservoir and piping properly arranged. The objection has also been raised that inasmuch as the control depends on the air supply, all cars would be disabled if the air compressor failed. This, of course, is true, but is regarded by many railway managers as an advantage, or at least as not in any way objectionable on account of the fact that when the compressor fails the air brakes are disabled, and it is unsafe to operate a car with the power brakes disabled. In cases of this kind, cars equipped with unit switch control may be coupled with the following car when it arrives and the two be operated as a multiple-unit train, that is, the motorman on the head car controls and operates both cars. When desired, an emergency or spare reservoir may be used, sufficient to take the car to the terminal or at least to a telephone siding or junction, in case the compressor fails. However, the great reliability and economy of this control on over a hundred roads demonstrates that this feature is negligible.

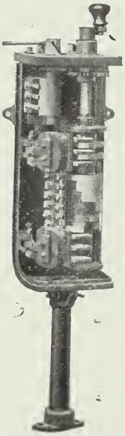


Fig. 1.
Master Controller.

TRAIN OPERATION

In addition to the advantages of the unit switch control for single car operation, one of the most important points in its favor is the ability to control two or more cars simultaneously. Multiple-unit operation, which is made possible by unit switch control, has a number of characteristics that greatly increase the operating efficiency of a system. Where multiple-unit trains are employed it is usually not necessary to have either cars of equipment as large as if they were operated singly at all times. In the effort to avoid train operation the size and equipment of interurban rolling stock has been increased to huge proportions. These big cars run most of the day with a small number of passengers for the sake of being able to handle the fifty or sixty who must be provided for on a few special trips. To make proper use of multiple-unit trains, a size of car more nearly suited to the average load may be employed and the capacity increased by coupling up when necessary. With equipments properly proportioned on this basis, there are probably few roads where two-car trains could not be run. Some roads may hesitate to employ multiple-unit trains on account of a supposed inadequacy of sub-station and feeder capacity, but the power requirements can be kept within very reasonable limits by proper training of the motormen. The cars on a certain line were equipped with two 150 horse-power motors, or a total of 300 horse-power each, and geared for a maximum speed of about 50 miles per hour. Great care had been taken in training the motorman on this line, and as a result the maximum current per car rarely exceeded 350 amperes. Where the motormen have not been instructed, currents of over 600 amperes have been noted on cars with the same equipment. It is quite evident from these figures that two-car trains in the hands of the first set of men could have been operated with peaks little or no higher than those caused by single cars in the hands of the second set.

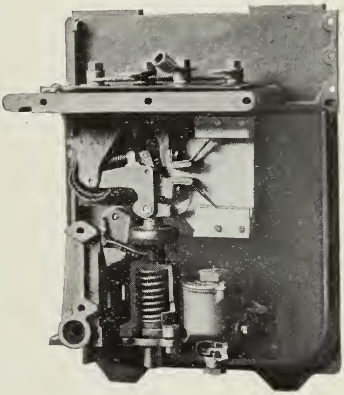


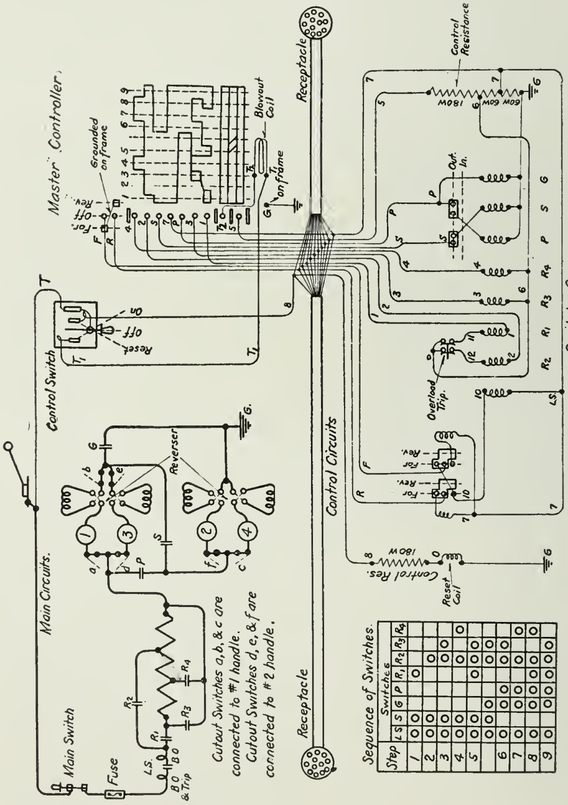
Fig. 2.
Unit Switch

Further, multiple-unit cars are able to move independently, and the making up of a train can be done with a minimum of shifting as compared with the use of trailers. At stub end terminals either car may be used for the leading car. If the motors were originally applied correctly there will be no danger of overloading them since the weight carried per motor is uniform. Thus it is possible with this uniform motor loading to apply the motors more efficiently as to size and gear ratio than if trailer operation had to be provided for, and smaller motors, geared for lower speeds, can be used for a given car schedule. Thus, for handling varying crowds, and still maintaining a close schedule, the employment of trailers, even under favorable circumstances, becomes a temporary expedient when compared to multiple-unit operation.

The advantages of train operation are not by any means confined to saving in power and flexibility of equipment. The operation of two single car units requires four men to two cars, while the operation of a two-car train requires only three men for two cars, thus effecting a saving of 25 per cent in labor. Where the traffic is necessarily congested, as in the center of a city during the rush hour periods, single car operation does not permit of the maximum use of the tracks.

TYPES OF UNIT SWITCH CONTROL

Four types of unit switch control are in common use, the classification depending upon the method of applying the power to the unit switches. These are:



Sequence of Switches.

Step	Switches							
	LS	S	G	P	R₁	R₂	R₃	R₄
1	○	○			○			
2	○	○				○		
3	○	○				○	○	
4	○	○				○		○
5	○	○			○	○	○	
	○	○	○			○	○	
6	○		○	○		○	○	
7	○		○	○		○		○
8	○		○	○	○	○		○
9	○		○	○	○	○	○	

Fig. 3.

Diagram of Connections for Controlling Four 75 H. P. Motors or Less.

1. Hand-operated line voltage control, known as *HL*. The master controller has as many points as there are control positions and a separate reversing handle.

2. Automatically operated line voltage control, known as *AL*. The master controller has three points forward and three reverse, corresponding to switching, series running and parallel running.

3. Automatically operated battery voltage control, known as *AB*.

4. Hand operated battery voltage control, known as *HB*.

These types of control are all suitable for multiple-unit operation and each possesses all the advantages enumerated for the Unit Switch Control.

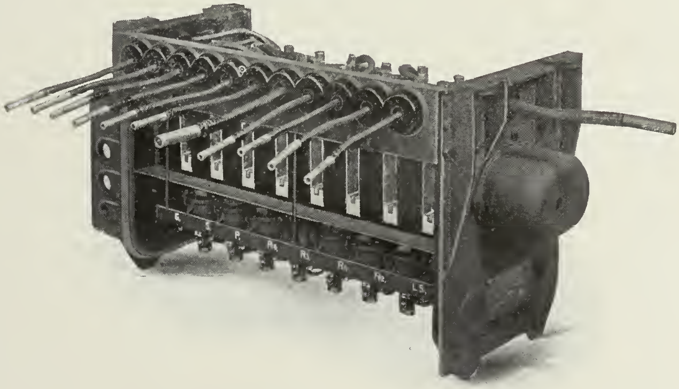


Fig. 4.
Switchgroup for H. L. Unit Switch Control.

Type *HL* control has been especially designed for service where apparatus of a simple character is required. On this account, various features, such as automatic acceleration, bridging transition, etc., have been omitted. These features are not essential to the success of service for which the equipments are intended, particularly where simplicity of parts is desired. This is the type of control which is in most common use for city and light interurban service, where light weight and cheapness are prime considerations; where the trolley voltage is fairly uniform; and where automatic acceleration is not necessary. This type of control is so arranged that trains may be made up of two or more cars, but generally not exceeding five motor cars, and the train may be operated from either end of any motor car.

The main circuit connections are made by means of a number of independent, pneumatically operated switches, known as unit switches, each provided with a strong magnetic blow-out, and normally held open by a powerful spring. In small equipments, all of the unit switches are mounted on an iron frame known as the switch group, and two of the switches in the group act as circuit breakers. Large equipments are provided with a two-unit line switch which performs the functions of an automatic circuit breaker and is mounted on a separate frame from the switch group. The overload trip that controls the opening of all switches in case of overload or short-circuit, is mounted on the end of the switch group, or line switch when separate from the switch group. This trip is actuated by the magnetic pull produced by one of the blow-out coils in the main circuit. When a predetermined current value is exceeded, a plunger carrying two contact discs breaks the control circuit which causes certain switches to open in the line switch and switch group. This plunger, when drawn in, is held by a latch and cannot be released until the control switch in the cab is reset. This can only be done when the controller is on the "off" position. This trip can also be reset by pulling a wire hanging through the overload trip cover, attached to the relay armature, which releases the plunger from the hold of the latch and again establishes the control circuit through the trip. Then to energize the control circuit the control switch need only be placed in the "on" position and the master controller notched up to start the train.

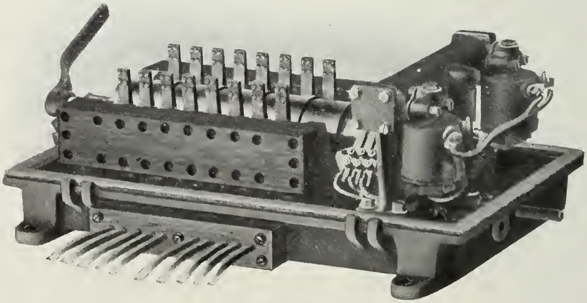


Fig. 5.
Standard Levers for H. L. Control.

A pneumatically operated reverser controls the direction of operation of the car. This reverser consists of two pistons similar to those attached to the unit switches, which serve to move the reverser drum to the forward or reverse position.

Junction boxes are used for making connections between the train line and branch control circuit to the various pieces of apparatus on each car. Connecting into these junction boxes is a multi-conductor train line which extends the length of each car and ends in a multi-point receptacle at each end. The train line is made continuous throughout a number of cars by connecting adjoining train line receptacles with a multiple-conductor train line jumper. The train line is rendered safer and the whole equipment more reliable by the arrangement of the control resistance. This resistance is not connected in series with the magnet coils, but is connected in shunt across the line when the master controller is "on," and the magnet coils are operated from low voltage taps. Thus, normally, only one of the train line wires carries full trolley voltage, while the remainder are subjected to voltages of one-third or less, instead of all the auxiliary circuits being operated at full line voltage. The master controller consists of a small drum controller with the main and reverse handles interlocked which safeguards against any false operation.

The extensive adoption of this type of control has been due to its simplicity, accessibility, ruggedness, and powerful action, embodying the fewest and simplest parts possible. Except on large equipments, the switch group and the reverser cover the entire main circuit parts. The arrangement of these as separate items instead of in the same frame enables both to be made much more accessible for inspection or repairs and permits a better balance to be obtained when the apparatus is mounted on small cars.

The *AL* type of control has three important advantages due to its automatic acceleration feature, namely:

1. Safety to motor equipment.
2. A predetermined rate of acceleration.
3. Comfort to passengers (with high powered motors).

This type of control is especially adapted for operation on elevated roads, in subways, and trunk-line interurban service, particularly with trains made up of a number of cars equipped with high power motors, where no severe grades are encountered.

The essential difference in this equipment over the hand operated control is that the acceleration of the train is secured automatically. The master controller has only three positions, which are "switching," "series running," and "parallel running." The "off" position is in the center. The unit switches are provided with interlocks which are electrically connected with the valve magnets which actuate the unit switches in such a manner that the closing of one switch energizes the magnet of the next, thus producing automatic progression of the switches under the direction of the limit switch. The limit switch controls the rate at

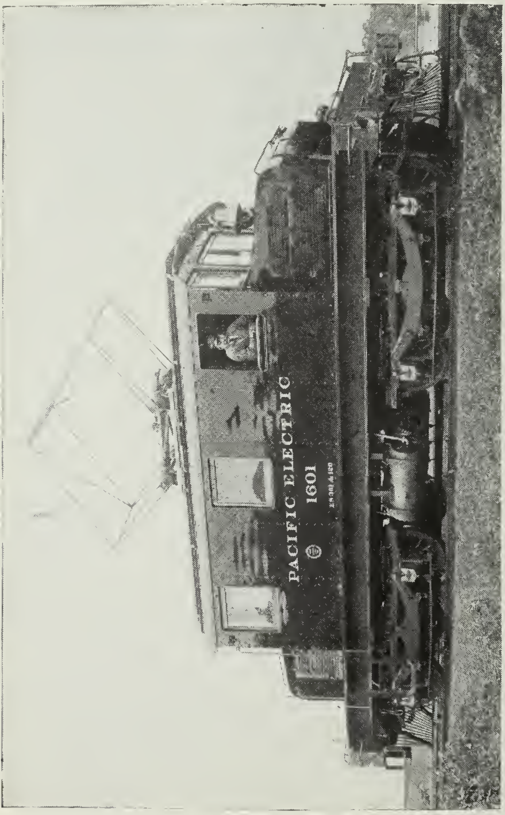


Fig. 6.

Baldwin-Westinghouse Locomotive Equipped with Commutating Pole Railway Motors, 600-1200 V. and Type H. L. Unit Switch Control.

which the resistance is cut out of circuit, so as to give uniform accelerating current. This produces smooth and economical acceleration and prevents the abuse of equipment by accelerating in excess of the predetermined rate. The limit switch consists of a solenoid operated by the current of one motor or pair of motors. When this current exceeds a predetermined limit for which the switch is adjusted, the circuit is opened through a pair of contacts in the operating circuit. The circuit remains open, so that no further unit switches can close until the accelerating current falls below the predetermined limit when the control circuit is again closed, thus allowing the unit switches to continue their progression. Should the overload trip open the control circuit, it is reset by the plug switch in the master controller, the plug being attached to the controller by a chain.

FIELD CONTROL

Field control is a system of regulating the speed of a direct-current series motor by varying the effective field turns. This is accomplished by using motors having a greater number of turns in the field winding than are ordinarily employed, and by arranging the control so that on certain notches a portion of the field winding is cut out of the circuit. With motors thus equipped, cars or locomotives can start heavy loads with small current consumption, and also can run efficiently at high speed when desired. A two-motor equipment has four efficient speed notches on the controller, which enables the same equipment to be operated with a minimum loss in either local or high speed service. Trains may be started with much lower accelerating currents and will run on resistance a smaller portion of the time. Thus a double saving ensues. When the entire field winding is used, the motor can produce large tractive efforts at low speeds with moderate current input. This enables it to start and accelerate a car very smoothly. When a portion of the field winding is cut out, the characteristics of the motor are modified just as if the gear ratio had been instantaneously changed. When connected in this way, the motor attains higher speeds than with the full field winding in use, and while this "normal field" is not so well adapted for starting the car, it is much better adapted for producing a high maximum car speed. In this way a given equipment can be made to operate more nearly under ideal conditions both in starting and in free running than if it must be arranged on some compromise basis. This arrangement is particularly advantageous for city and suburban service where a large number of service stops are made. Under such conditions there is, with field control, a saving of 8 to 15 per cent in power consumption. Field control is also advantageous for interurban equipments which are sometimes operated in local and sometimes in limited service. Its use in such cases enables a single motor equipment to be readily arranged so as to give good results in both classes of service.

Field control virtually produces a high speed equipment which has an extremely small rheostatic loss in starting. The saving in energy will depend largely on the amount that is ordinarily lost in resistance. Inasmuch as higher speeds are possible, the time of coasting is usually longer with field control, and another saving is thereby effected through the reduction of braking losses. There is also a slight economy in weight, as a decrease in resistance loss insures that there will be less resistance to carry. In some cases, with field control, the motor is also lighter.

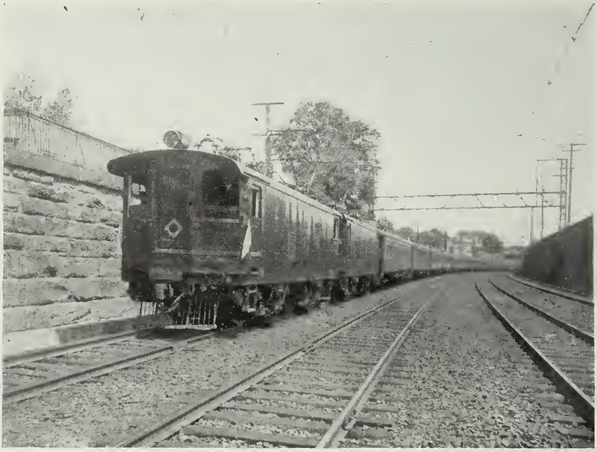


Fig. 7.

Locomotive Equipped with Field Control Single Phase Motors and Unit Switch Field Control.

The first important installation of field control on locomotives was that on the passenger locomotives placed in service by the New York, New Haven & Hartford Railroad five years ago. When operating in the direct-current zone, the speed is regulated by field control. The method proved so satisfactory that, when the time came, the same plan was adopted for the locomotives for the Pennsylvania Railroad Company's New York City extension, and its success has been equally great with these engines. Through the use of field control, the Pennsylvania locomotives have the advantage of both high-speed and low-speed machines. The full field gives an enormous tractive effort at slow speeds with relatively small current and the normal field permits the locomotive to haul comparatively heavy loads at high speeds. Numerous installations with this type of control have since been made on both city and interurban lines, and its fitness on commutating-pole motors has been demonstrated.

SAFEGUARDING A MOUNTAIN RESERVOIR.

G. E. Martin, '09.

, The City of Colorado Springs depends for its water supply upon the streams on the eastern and northern slopes of Pike's Peak. These streams, in turn, are fed and their flow regulated by the melting snow on the mountain peaks. For storage, in addition to that furnished by the snow, the city owns a series of six reservoirs, ranging in elevation from 10,215 to 12,080 feet above sea level. The altitude of Colorado Springs is 6,000 feet.

Reservoir No. 4, of the Colorado Springs Water System, is the largest in area of the six reservoirs. Like the remainder, it is a natural lake basin, which has had its water level raised by means of a dam across the outlet. The area inside the high water line of the reservoir is 120.93 acres, and its capacity is 864,544,800 gallons. It was begun in 1903 and completed in 1904, at a cost of $160,000. The basin is about 4,800 feet long and 900 feet wide, with the long axis bearing northwest. The elevation of the reservoir is 10,930 feet above sea level.

The dam at Reservoir No. 4, exclusive of the waste weir, is 1331 feet in length, and is built in a straight line perpendicular to the direction of Boehmer Creek, the outlet of the reservoir, at that point. The highest portion of the dam is fifty feet high, and it is 185 feet wide at the point where it crosses Boehmer Creek. The soil at this point is disintegrated granite, and since it is impossible to build a water tight dam of this material, a concrete core, puddle trench and puddle wall was placed in the dam. The crest of the dam is eighteen feet wide. The puddle trench was placed directly beneath the crest of the dam and is five feet wide on the bottom and eight feet wide at the original ground surface. The trench was filled with the best selected sand and clay which could be obtained at the dam site. The concrete core was placed about six feet from the intersection of the inner edge of the dam with the stream bed. The core is 14 feet 2 inches high, 3 feet thick at the bottom and 1 foot 6 inches thick at the top. It extends nine feet below the bottom of the dam and surrounds the outlet pipe. The inner slope of the dam is 2½ feet horizontal to one foot vertical and is covered with a puddle face and rip-rapped with granite stone one foot thick. The outer face has a slope of 1½ to 1. The crest of the dam is seven feet above the top of the waste weir. Such, in brief, is the original design of the dam. It was constructed essentially along these lines, except that a puddle core was added in the center of the dam above the puddle trench. Figure 1 is a view looking up stream toward the dam.

Seepage through and around the dam was so great that the reservoir was useless for storage for a number of years. However, percolation so filled the dam, in time, that part of the reservoir could be used for storage purposes, though it had never been entirely filled.

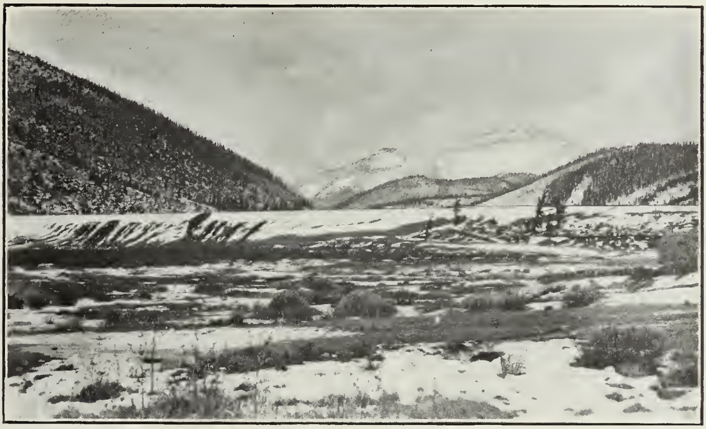


Fig. 1.

Dam No. 4 from Below the Reservoir.

In the spring of 1912, Mr. B. B. McReynolds, the Water Superintendent, began to fill the reservoirs to their maximum capacity, and thus obtain for the city the storage for which it had paid. In attempting to increase the storage of Reservoir No. 4, Mr. McReynolds was confronted, on the morning of June 22nd, 1912, with a series of leaks which had developed on the down stream slope of the dam, at a distance of 26 feet below the crest, and extending across the major portion of the dam. The location of these leaks can be seen from Fig. 1. At this time the level of the water in the reservoir was still four feet below the high water line, or the level of the spillway. This condition is shown in Fig. 2, which is a view looking across the reservoir toward the inner face of the dam. The spillway is to the right. Figure 4 is a near view of the largest one of the leaks. Had these leaks not been discovered in time, the whole dam would undoubtedly have been destroyed. In addition to the financial loss of the dam itself, the efficiency of the entire water system would have been impaired. Also a disastrous flood, with great loss of life and property, might have been incurred in the valley below the dam. The city was threatened with legal proceedings by the property owners below the dam, and so the water was drawn down to a safe height, and the reservoir left in that condition for the summer.

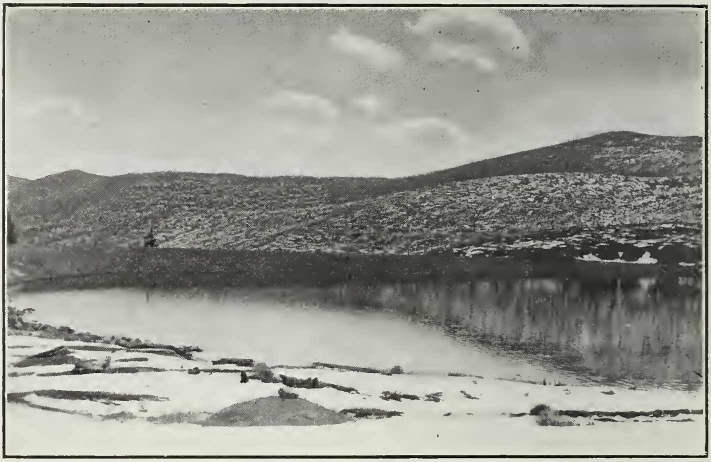


Fig. 2.

View of Dam from Above Reservoir.

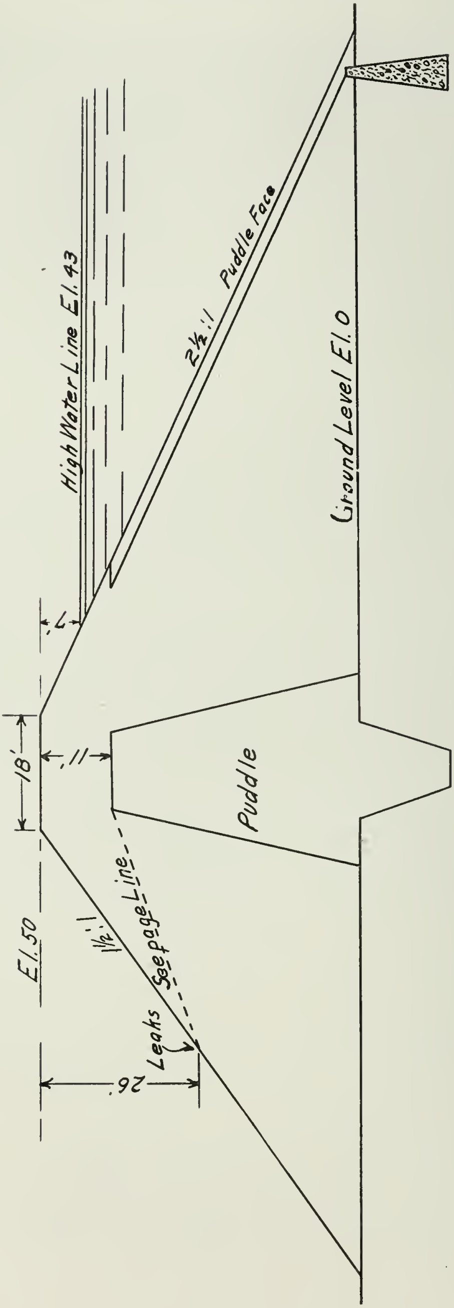
The next proposition was to discover what was the cause of the threatened destruction of the dam, and how it could be remedied. In conjunction with City Engineer F. F. Mallon, a report was made on these two subjects. An examination of the dam revealed that the puddle core extended only up to a point eleven feet below the top of the dam, or four feet below the top of the spillway. The puddle face also stopped at the same height. With these facts in mind it is easy to see what happened when the reservoir was filled. The water passed over the top of the puddle face and saturated the portion of the dam between the face and the puddle core. It then passed over the top of the puddle core, through the remaining portion of the dam and out to the surface at a point 26′ below the crest of the dam. The water immediately began to wash away the loose material composing the dam.

The necessity for the reconstruction of the dam, or its alternative, the lowering of the spillway, becomes quite apparent from several view points. So long as the reservoir cannot be filled the city is not receiving a proper amount of storage for the money invested. Also a future water superintendent, ignorant of the instability of the upper eleven feet of the dam, and the experience through which Mr. McReynolds has just passed, might attempt to raise the water in the reservoir to the spillway and thus cause the destruction of the dam. Again, there is a smaller reservoir, No. 2, about a mile and a half up Boehmer Creek from No. 4. Should the dam of No. 2 fail for any reason, with No. 4 capable of storing but 32 feet of water, the latter dam would be a total loss before the water in the reservoir could be raised to the level of the spillway, This in spite of two outlets from the reservoir.

Since the reconstruction of Dam No. 4 seems to be an absolute necessity, it might be well to consider the defects in the original design and ultimate construction, in connection with the proposed methods of remedy. If the defects are rectified during the course of rebuilding, the dam will undoubtedly render efficient service.

The ideal earth dam is an immovable mass overlaid with an impermeable face, and free from saturation. Though the ideal earth dam is an impossibility, the closer we approach this idealism, the more efficient the construction becomes. So it is true of Dam No. 4. If the original design be sufficiently altered, the puddle core and puddle face brought up to a proper height above the spillway, and adequate drainage provided at the rear base, the more exempt from saturation the dam becomes, and hence the more stable.

From the measurements of the seepage found at the toe of the dam, the concrete core has evidently not fulfilled its purpose. Doubtless it does not extend far enough into the hills at each end of the dam to cut off the water. However to remedy this would require the complete tear-



Cross-Section of Dam

Fig. 3.

ing down and reconstruction of the dam. The up-stream slope is 2½ feet horizontal to one foot vertical, while the down stream side shows a batter of only 1½ to 1. Had these slopes been reversed and the other defects remedied the seepage would have been materially decreased and the line of saturation much lowered.

To point out the fundamental defects of an earth filled dam is only one phase of the problem, while the economical rectification of these defects is still another. Undoubtedly the following plan is not the only one that could be suggested, but it seems to have more merit than any of the alternatives considered. Several engineers have examined Dam No. 4, at different times, and their solutions of the problems have varied widely; the majority of them involving as large an outlay as for the original construction of the dam. Control of the saturation is of prime importance in either the building or the reconstruction of an earth dam. Lines of saturation are inevitable in earth dams, due to the percolation of the water from the reservoir, and to sub-saturation from the foundation. An earth dam without a core wall has only a small portion of its cross sectional area of dry material, and even this rests upon an unstable saturated mass. It is therefore quite apparent that a dam resisting a high hydro-static pressure is likely to slip when the up stream prism and the foundation is thoroughly saturated; therefore, since the core of No. 4 is improperly constructed, it is to be concluded that the existing conditions are about as herein described. The steepness of the rear slope of Dam No. 4 leaves a decidedly small quantity of material unsaturated. This proves that the rear slope is entirely too abrupt to permit the presence of a sufficient quantity of dry material to render effective weight to oppose the pressure of the water. For as soon as the material in the dam becomes saturated it loses its effective weight in proportion to its buoyancy. Thus, if the material were open gravel, as in this case, weighing when dry about 120 pounds per cubic foot, it would weigh but 84 pounds per cubic foot when saturated. This is allowing 40% for voids.

The reconstruction of Dam No. 4 should, therefore, comprise the bringing up of the puddle core wall and puddle face, with suitable material, to within five feet of the crest of the dam, at least, in order to insure against future leaks and to increase the general impermeability of the structure. The line of saturation would thus be lowered. Also the down stream slope should be reduced to 2½ to 1 or still better 3 to 1. In order to still further reduce the line of saturation, provision should be made to install in the rear of the embankment a longitudinal drainage ditch filled with boulders and broken stone. Leading from this trench, at right angles, several smaller trenches should be constructed, in the same manner, in the foundation on which

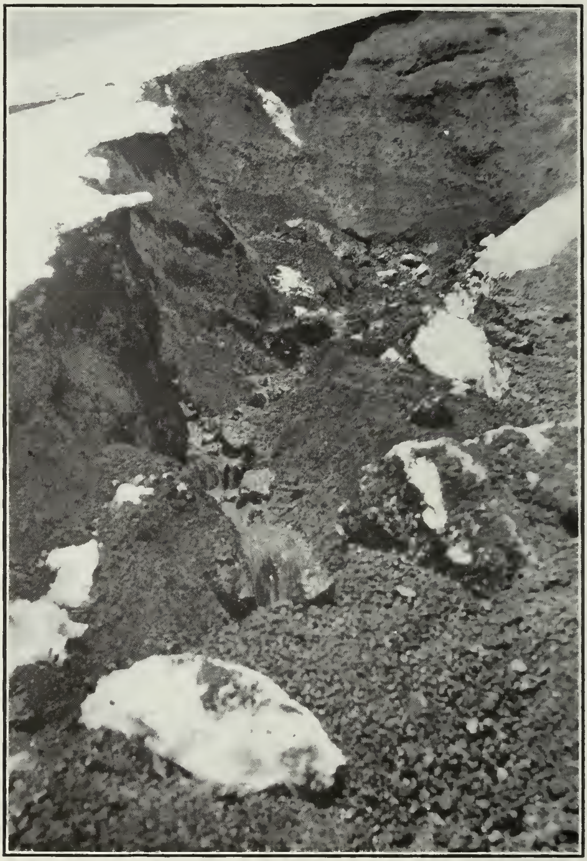


Fig. 4.
Leak in Dam No. 4.

the new slope will rest. These should terminate in the toe of the new embankment.

With these changes the stability of the dam will be greatly increased and further danger of its failure, under normal conditions, will be entirely eliminated. The proposed method will not prevent seepage however. Seepage is apparent at the toe of all earth dams, to a greater or less extent, either through the embankment, through the foundation, or through the side hills. There is no doubt but that the seepage through the artificial portion of the dam would be materially reduced. When this is done the present problem is solved. The scheme of reconstruction as outlined in the preceding pages provides for the work being done without lowering the water in the reservoir. The cost of the improvement should not be over $15,000, itemized as follows:

15,000 cu. yds. of grading at 65 cents	$ 9,750.00
2,000 linear feet of rock filled trenches at $2.00	4,000.00
1,000 sq. yds. of rip rap at $1.00	1,000.00
Relocating valve house	250.00
Total	$15,000.00

THE MECHANICAL HANDLING OF MATERIAL

I. H. Barbee, '08

The application of machinery to the handling and conveying of heavy and bulky material has of late years assumed a paramount interest. No branch of engineering has so rapidly developed in modern times as the construction of appliances for loading and unloading heavy and bulky substances, such as coal and crushed rock. The increased competition encountered by the manufacturer has forced upon him the necessity of economy in handling of his materials in all branches of manufacture. Labor saving appliances are regarded as absolutely essential to the progress of all industries. In the introduction of machinery for the automatic handling of materials, America has no doubt taken the lead on account of the peculiar conditions of this country, where the saving of high priced labor is of so much more importance than in other countries. In round figures it may be taken that the saving of one man's wages warrants the investment of $4,000.00 in machinery, so that, in his quest for economy, the engineer is ever on the alert to reduce the wage bill and handle everything automatically. It would be rash to assume that the increase of mechanical appliances is detrimental to the interests of the worker; on the contrary, experience has shown that his daily life is thereby made easier, his intelligence improved and his wage earning capacity increased.

The subject as a whole is a very extensive one and may be divided into two main topics as follows: First, installations which handle the material continuously, that is, receive and deliver it in an uninterrupted stream—such installations as bucket elevators, barrel elevators, spiral and belt conveyors, and second, installations which serve to handle material intermittently, such as grab buckets, used in loading and unloading coal and ore from boats, skips for the handling of concrete, or ore in reduction furnaces, and cranes.

This article is intended to treat principally with installations of the first mentioned or continuous type. The subject of handling materials continuously may be classified under three heads: first, appliances for lifting in a vertical direction, from one level to another, commonly called elevators; second, appliances for moving material in a horizontal direction, commonly called conveyors; and third, appliances which combine the two former by elevating and conveying the material horizontally at the same time. Conveyors are further subdivided into appliances consisting of a fixed trough in which the material is conveyed by means of some pushing agent, or into appliances in which the trough containing the material moves bodily.

ELEVATORS.

Elevators in a primitive form have been known and used for a very considerable length of time, and since their introduction have undergone little alteration except in details. The term "elevator" is usually applied to endless belts or chains to which are attached a series of suitably shaped receptacles or buckets. These chains or belts run over two terminal pulleys which are fixed at different levels. The distance from the centers of these pulleys is usually called "centers," and sometimes "the length of the elevator." Elevators are designed to suit special purposes, but are with few exceptions provided with adjustable bearings or takeups, which are usually arranged at the lower or boot end. The elevator

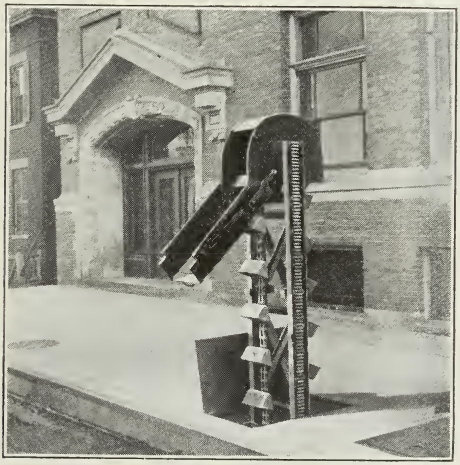


Fig. 1.
Telescopic Ash Elevator.

is driven at the delivery end of the elevator. The tightening of the chain might disturb the driving arrangement if it was placed at the lower end. An elevator should always be fed from that side on which the buckets ascend, so that the stream of material runs into the elevator buckets, meeting them on their upward path. For elevators of large capacity it is sometimes necessary to have a very wide bucket, and whenever this necessity does arise, it is advisable to use double strand chains which fasten either to the end or the back of the bucket by suitable attachment.

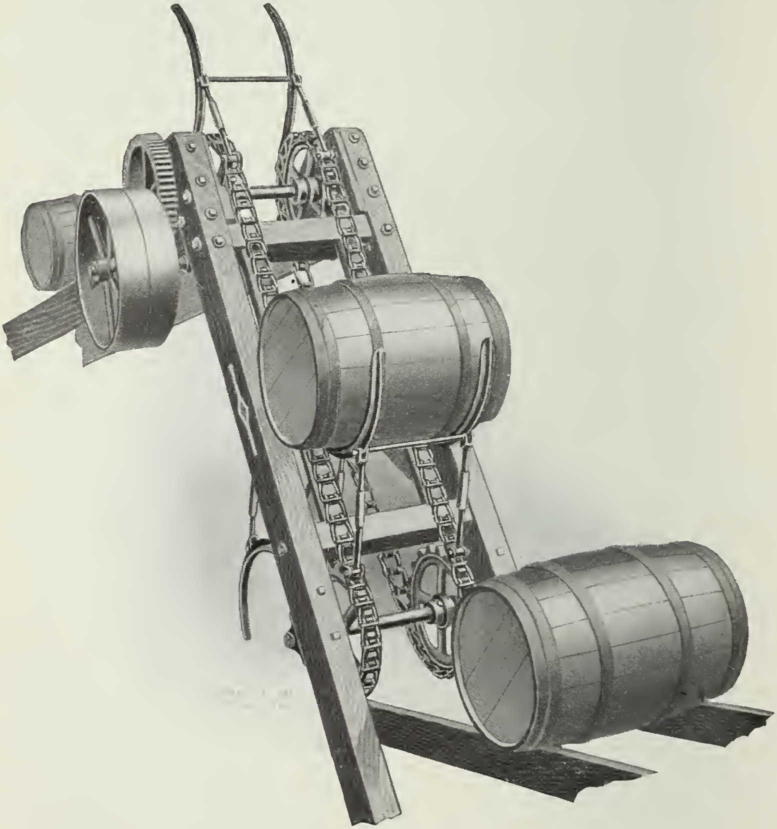


Fig. 2.
Barrel Elevator.

A very economical form of elevator is one fitted with a continuous chain of buckets. This type is naturally of a much larger capacity than an ordinary elevator of the same dimensions. It takes and delivers its load with more uniformity, and as the buckets need not plow intermittently through the contents of the elevator boot, smoother running is secured. It is advisable to vary the shape of the bucket for the different products they have to handle. A shallow bucket is best for soft and clinging material such as flour, while for harder materials such as wheat a deeper bucket will be found preferable. A novel type of bucket elevator is that of the telescopic type used to handle ashes. When it is not in use it may be telescoped into the basement and the manhole closed in the sidewalk. These are used quite extensively wherever it is impossible to install an ash elevator of the stationary type. The usual type of barrel elevator is shown, and it is so self-explanatory that it will not be necessary to explain its operation. The Chain Belt Company has worked out and patented a very successful single strand barrel and box elevator. This type has found particular favor among the breweries on account of the minimum amount of floor space it occupies.

CONVEYORS.

There are many types of conveyors. The oldest perhaps is what was known in olden times and is still known as the worm or screw conveyor. The screw conveyor consists today of a spiral piece of steel wound round a solid shaft or pipe and riveted to the pipe. The sections of conveyor are coupled by means of gudgeons at which the bearing is also placed.

The next type of conveyors to be considered are those of the drag or push plate type. Most of what has been said in reference to elevators also applies to scraper conveyors. This conveyor varies much in minor details of construction, but in principle it consists of a fixed open trough of wood, steel, or iron. The material to be conveyed is deposited in this trough and is pushed or scraped along by a series of plates attached to an endless chain which revolves over head and tail sprockets. Belt conveyors present an acceptable form if they can be adapted to handle the material. The advantage over other types is that they carry the material rather than drag it and do not cause breakage of the material. They present the one disadvantage, however, of not being able to discharge their given load at any particular place with all materials. For handling grains it has a decided advantage as the intermediate discharge is effected by means of a traveling tripper. The carrying side of the belt is usually supported by concentrator pulleys so as to form a trough, while the return is over flat pulleys. There must necessarily be a condition under which belt conveyors can no longer be effectively used and that is when sharp and cutting material has to be handled. In such cases it is usual to employ flight conveyors made with steel or iron flights mounted on a double strand of roller chain belt. Usually these flights are curved on each end, and are made concentric with the center of the

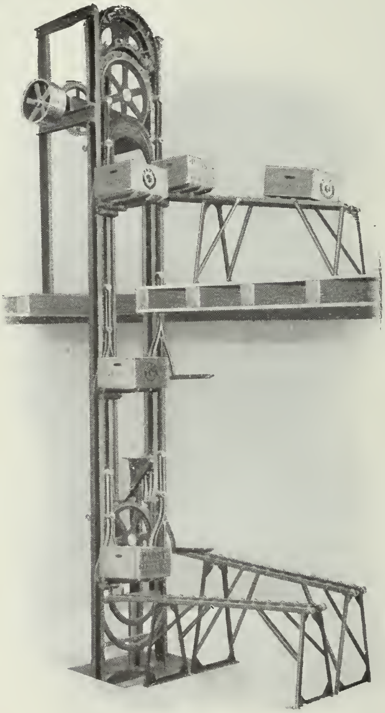


Fig. 3.
Box Elevator.

chain pin. For this reason this particular type of conveyor receives its name "Beaded Flight Conveyor."

Probably the most accepted form of conveyors in general use today for coal handling are the gravity discharge and the pivoted bucket systems. The gravity discharge is composed of a V shaped bucket rigidly attached to a strand of chain on each end. When traveling in a horizontal direction it scrapes, and when traveling in a vertical direction it acts as an elevator. When traveling horizontally it is necessary to provide a trough and the material is discharged through the openings at the desired points. The pivoted bucket is made up of a bucket with trunions on each end fitted into strands of chain belt. The buckets are free to swing, and the center of gravity of the bucket is below the pivot point at all times so that the bucket remains horizontal. When it comes into contact with a traveling tripper at the discharge point, the tripper simply overturns the bucket, its contents are discharged and the bucket swings back to its horizontal or normal position. Of the two systems the pivoted bucket is the more desirable because it is less noisy and carries the material rather than scrapes it. On the other hand it is more expensive to install.

In conclusion it might be said that there is no exact rule that can be laid down in planning machinery of this class. It is necessary that a careful study be made, not only of the material to be handled, but surrounding conditions of installation, and above all the class of men who will have to do with the installation afterwards, as it must by all means be fool-proof.

CARBON CONTACT RESISTANCES.

C. R. Moore, '07

A few years ago the writer became interested in the well known micro-phonic phenomena of carbon contacts and began a series of tests having for their object the determination of data which might be used for purposes of design. It must be recognized at the outset that a great many conditions affect tests of this sort so that in applying the data herein given, care must be taken to have similar conditions. However, in the opinion of the writer, this data is of value even in cases where different conditions exist, in that certain limitations are clearly evident.

The first of the tests mentioned above, i. e., those having to do with carbon plates under fairly heavy pressures such as are used in carbon plate rheostats and regulators have already been reported, so that this paper will deal with contact resistance of granular carbon only.

The most common devices in which granular carbon is used are telephone transmitters and micro-phones. Obviously the initial pressure and changes of pressure in devices of this kind are very slight so that one must take very great care in tests of the sort herein described to have an apparatus of the proper sensitiveness. It will be assumed at the outset that the construction of the ordinary transmitter and micro-phone is understood. So far as the writer is aware the changes of mechanical pressure on a diaphragm caused by ordinary sounds have never been reduced to figures so that the general scheme followed was to study the pressure-ohm characteristics of the carbon cell itself and from these data deduce values of pressure change which must occur in speech transmission.

The apparatus designed by the writer for making these tests is shown in Fig. 1. This device is essentially a scale beam weighing machine in which means are provided for varying the load at one end without touching mechanically the apparatus as a whole. The base carries an upright support tipped with knife edges at *"B."* An accurately balanced beam rests upon this knife edge, and carries a pointer which moves over a scale, in the ordinary way. At one end of this beam (A) is hung an aluminum rod, round in cross section, and turned to that diameter which gives exactly one square centimeter cross-sectional area.

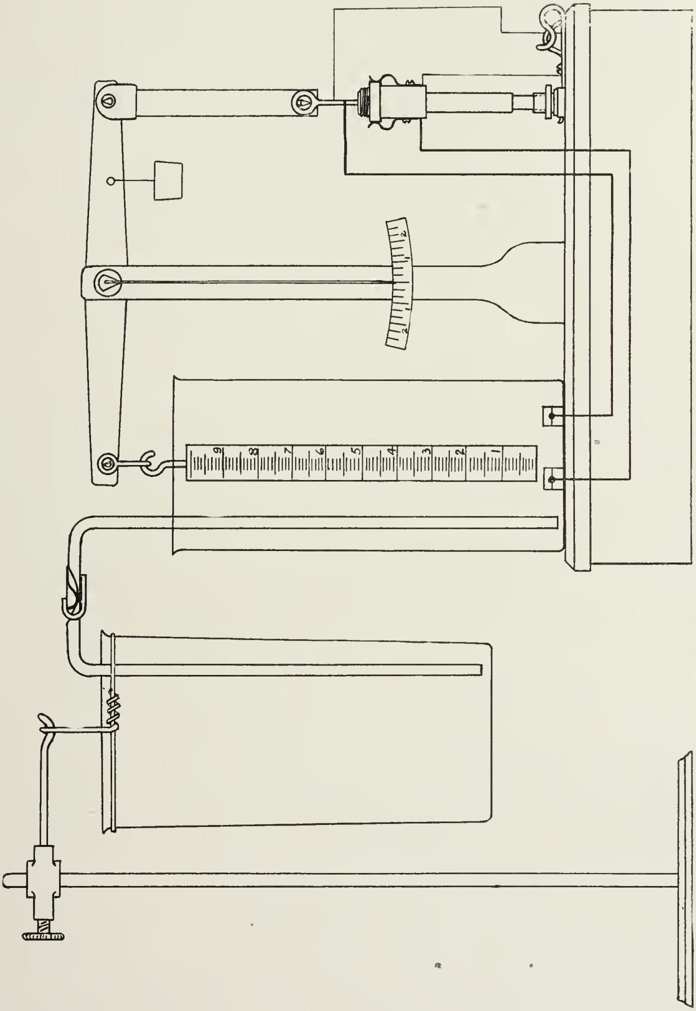


Fig. 1.

The rod has a centimeter scale marked upon it beginning at the lower end as shown. Glass beakers are arranged, one surrounding the aluminum rod, and one fastened to a support, the height of which may be varied. Water is poured into both beakers, and a siphon tube with hose clamp is arranged as shown.

Obviously the height of the water in beaker *E* may be varied by raising or lowering the beaker fastened to the adjustable support. From the construction, it is evident that a change of water level of one centimeter in beaker *E* produces a change of one gram in the forces acting on end *A* of the scale beam.

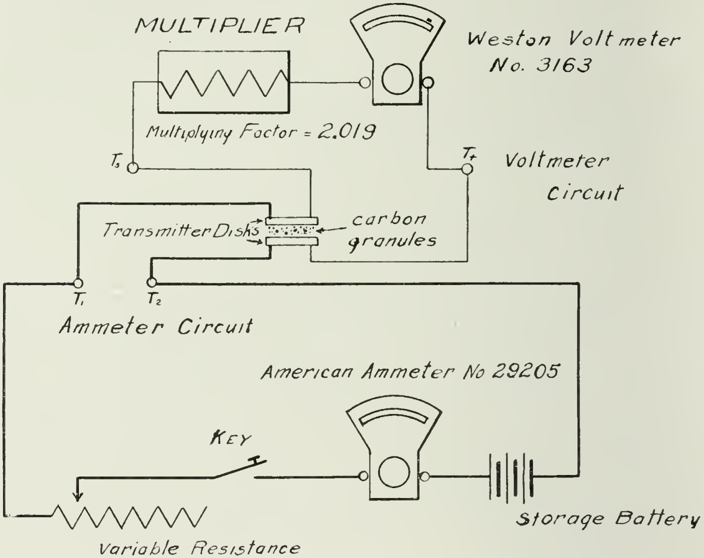


Fig. 2.

At *F* is hung a pan of shot which serves as a counterbalance. A small bar of wood extends from *C* and carries on its free end one of the electrodes of the carbon capsule under test. The amount of shot in pan *F* was adjusted until balance conditions were obtained. An upright of wood *R* fitted at the bottom with an adjusting screw carries the remainder of the carbon capsule and the other electrode. *R* may be raised or lowered by means of the adjusting screw and in this way practically zero pressure obtained, actual contact being indicated by a movement of the pointer.

Circuits were arranged as shown in Fig. 2 so that readings of current and voltage might be obtained as desired.

The procedure followed in making an observation is as follows: The beam is accurately balanced with the water in beaker *E* at the zero point of the scale. During this time, post *R* is in its lowest position and the beam is free to vibrate. When it has come to rest, *R* is raised until movement of the pointer begins, indicating that practically zero pressure exists at the electrodes. The level of the water in beaker *E* may now be raised to some desired pressure and readings of current and voltage at the electrodes taken. The top key shown is essential since the readings must be taken as quickly as possible. If this precaution is not observed heating effects develop within the capsule for which correction is difficult if not impossible.

The performance of the instruments in connection with this apparatus is of unusual interest. When the tap key is first pressed, the needle swings across the scale and then recedes a short distance due to interior effects. The needle will pause for a short time and then begin to crawl slowly downward. Another pause is noticeable after which the needle begins to crawl slowly upward. Finally, a constant value is reached after which there is no change in position. The above action is most pronounced when current values are low. With high current values from 0.3 amperes upward, the needle vibrates on each side of a definite point. These phenomena will be discussed later.

Data for these tests may be taken in three ways:

(1) Pressure constant, variable current. Calculate resistance.

(2) Voltage constant, variable pressure. Calculate resistance.

(3) Current constant, variable pressure. Calculate resistance.

The first method was used in these tests and seems to be the most reliable. The second and third methods involve heating difficulties in the capsule, which are troublesome. Furthermore, the third method involves a condition never met with in telephone practice. The range of voltages 1 to 4 used in these tests covers well the values used in practice. Surface tension of the water around the aluminum rod presented some difficulty at first, but after a little practice accurate values were quickly obtained. Various corrections were made covering standardizing of the instruments, current taken by the voltmeter, etc., in working up the data. The scheme, in general, is to measure the drop of potential across the capsule as values of resistance are easily computed by application of Ohm's law.

Curves given in Fig. 3 show variation in resistance with varying voltages. It will be noted that these curves show a critical voltage at which point the resistance reaches a maximum. All the curves taken are not shown but the greater part of them, including those given in Fig. 3, show that this critical value is about 0.5 volt, and is practically independent of pressure within the range of values used. This critical point will be discussed later.

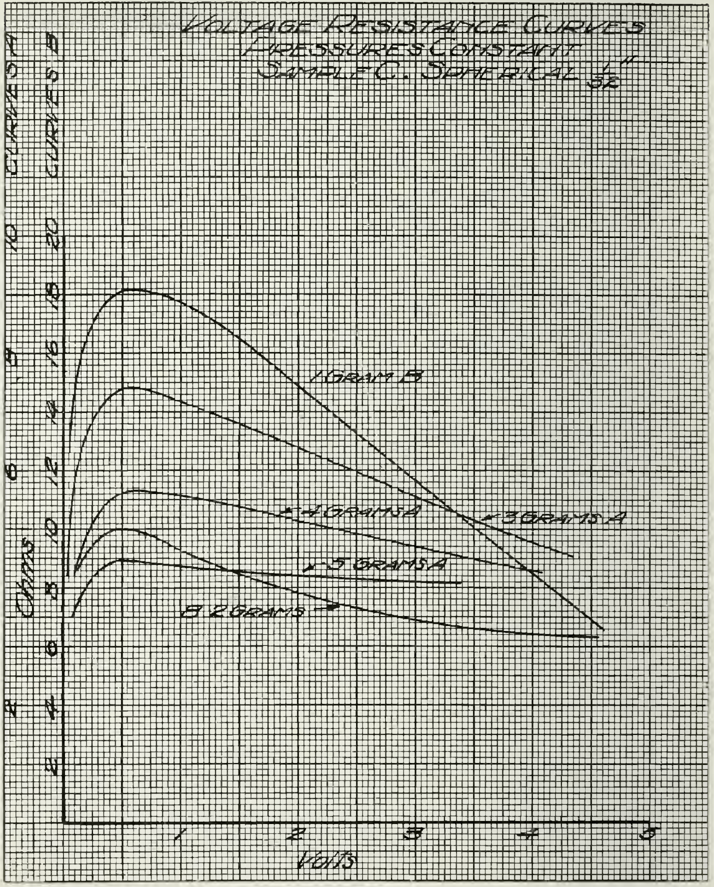


Fig. 3.

Figs. 4 and 5 show the shapes of the pressure-resistance curves. It should be noted that these closely resemble curves plotted according to the hyperbolic law. All seem to tend toward some constant value of resistance as the pressure is increased. This resistance is probably the inherent electrical resistance of the carbon itself.

In order to determine how closely the curves found by test approximate the true hyperbola, the theoretical curves were calculated and superimposed upon the experimental curves. Points found by calculation are indicated by small circles. A method for calculating the parameters of such curves is as follows: the general equation for the hyperbola to asymptotes parallel to any set of axes is

$$M = (p - A)\ (r - B)$$

where A = the initial pressure
B = the initial resistance.

Taking the co-ordinates of three points on the curve, this equation yields three equations, as follows:

$$\begin{aligned} M &= (p_1 - A)\ (r_1 - B) \\ M &= (p_2 - A)\ (r_2 - B) \\ M &= (p_3 - A)\ (r_3 - B) \end{aligned}$$

which solved simultaneously for A and B give

$$A = \frac{(p_2 - p_1)\ p_3\, r_3 + (p_3 - p_2)\ p_1\, r_1 - (p_3 - p_1)\ p_2\, r_2}{(p_3 - p_2)\ r_1 + (p_2 - p_1)\ r_3 - (p_3 - p_1)\ r_2}$$

$$B = \frac{(r_2 - r_1)\ r_3\, p_3 + (r_3 - r_2)\ r_1\, p_1 - (r_3 - r_1)\ r_2\, p_2}{(r_3 - r_2)\ p_1 + (r_2 - r_1)\ p_3 - (r_3 - r_1)\ p_2}$$

From the one volt curve in Fig. 4 the following values are chosen:

p_1 = 0.4 grams. r_1 = 92.0 ohms.
p_2 = 1.0 " r_2 = 45.5 "
p_3 = 2.0 " r_3 = 25.5 "

Substituting these values in the above equations gives $A = -0.132$ grams and $B = 2.35$ ohms as the asymptotes to the theoretical curve. These lines do not coincide with the original axes owing to the fact that absolute zero pressure was not obtained at the start and that the circuit contained ohmic resistance other than that of the carbon capsule itself. These asymptotes are shown as broken lines in Fig. 4.

Substituting these values for A and B in the first equation given gives

$$M = (.4 + .132)\ (92 - 2.35) = 47.65.$$

which may be used in calculating any theoretical point desired on the one volt curve. The agreement between the theoretical and experimental curves is shown by the fact that the calculated points fall almost exactly upon the curve plotted from the tests. These calculations were duplicated for the 3 volt curve shown in Fig. 5, where the agreement between calculated and experimental data was also very close.

In one well known make of transmitter two carbon disks each about 0.5 inches in diameter are spaced about 0.1 inches apart, one being fastened rigidly to a solid back and the other attached to a mica diaphragm. The space between is filled with granular carbon to an average level about 0.1 inches above the center line.

A little calculation shows that the center of gravity of the portion of the carbon disk in contact with the granular carbon is on the vertical diameter about 0.4 cm. below the level of the carbon particles. The area of carbon disk touched by the granules is about 0.8 sq. cm. and the center of pressure is about 0.65 cm. below the granular level. Applying the laws of hydrostatic pressure, considering the specific gravity of carbon as 2.25 and allowing for the interstices between the grains we have:

$$\text{Pressure on center of gravity} = .4 \times 2.25 \times \frac{\pi}{4} = .708$$

grams per cm. Total pressure acting on disk $= .708 \times .8 = .566$ grams. This force must of course be considered as applied at the center of pressure.

The resistance on the one volt curve of Fig. 4 for .566 grams pressure is about 90 ohms and on the 4 volt curve about 50 ohms. These values agree very well with those found in practice. It is therefore safe to assume that the initial pressures in granular carbon transmitters are in the order of one-half gram. It should be noticed that the resistance curve at this pressure has a very steep negative slope and that any further decrease in pressure raises the value very much; thus, for about 0.2 gram pressure the resistance will be measured in hundreds of ohms. Furthermore, a very slight change of pressure at this point makes a great change in this resistance value and herein lies the secret of microphone action.

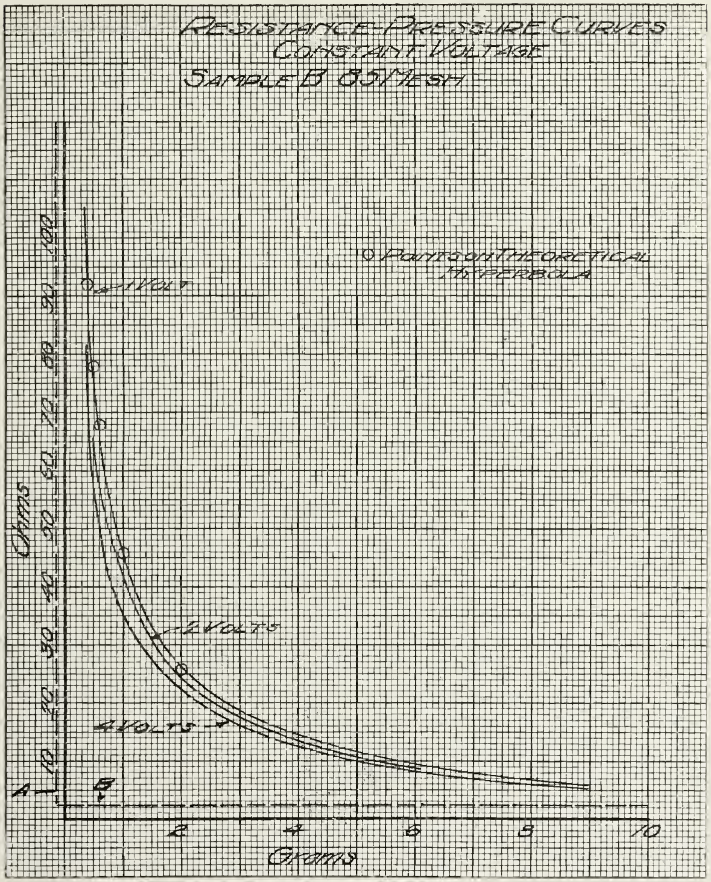


Fig. 4.

Experiments have been made in which the tread of an ordinary house fly has been made to sound very much like a trotting horse, and sounds entirely inaudible to the unaided ear have been easily heard through the receiver.

The theory underlying this interesting phenomena has been very much discussed, and nearly all writers agree that the effect is due to change of area of contact with pressure. Some have likened the change of area of contact surface with pressure to the effect shown by pressing a billiard ball gently or with considerable pressure upon a hard smoked surface. A small black dot is given to it with light pressure, but a black area of considerable size results when the pressure is heavy. The microscopic character of the surface of the carbon particle seems to have been entirely overlooked.

If one will but take the trouble to examine under a high power microscope the carbon surface which exhibits the most pronounced microphonic action he will find that this surface presents very broken and rough appearance not unlike a pile of loose coal the chunks of which vary from slack to lump size. The writer has examined several carbon granules, taken singly and magnified to approximately 600 diameters, and all show the same character of surface, i. e., very much broken, covered with peaks, cliffs and small rectangular points jutting out in every direction. To the naked eye these granules looked perfectly smooth. It is to these minute peaks and spires that particular attention should be called. The carbon particle is very elastic so that very light pressure between two granules brings only a few of the peaks or points into actual contact but a slight increase in pressure will bring into play many more peaks or points having lesser height from the main body of the particle and thus lower the resistance considerably. Through the microscope it is easily seen that the high peaks are few in number but the foot hills, so to speak, are numerous. Therefore as the pressure is still further increased, lower peaks are brought into play in increasing numbers until finally a point is reached where a considerable part of the particle surface is in actual contact. From this point on, the billiard ball analogy probably holds, but for pressures below this the peaks evidently play the major part.

The data herein given shows that the resistance is also lowered with increase of voltage, a phenomenon which is due to the peaked character of the surface. For a given mechanical pressure let us suppose that only a few of the highest peaks are in actual contact. If now a low voltage be impressed on the particles, a current will flow, the points become heated and their individual resistances are reduced; i. e., carbon has a negative temperature coefficient. Any further increase in voltage increases this effect.

For the lighter mechanical pressures, however, a more or less pronounced critical votage exists such that further increase or decrease of voltage will lower the resistance. In this connection the wedging action of the points one on the other must be considered. A low voltage will cause just current enough to flow, let us say, to heat the tips of these peaks only, radiation from their sides being sufficient to prevent the main body of the jut or spire from being appreciably heated. The points are then weaker mechanically and

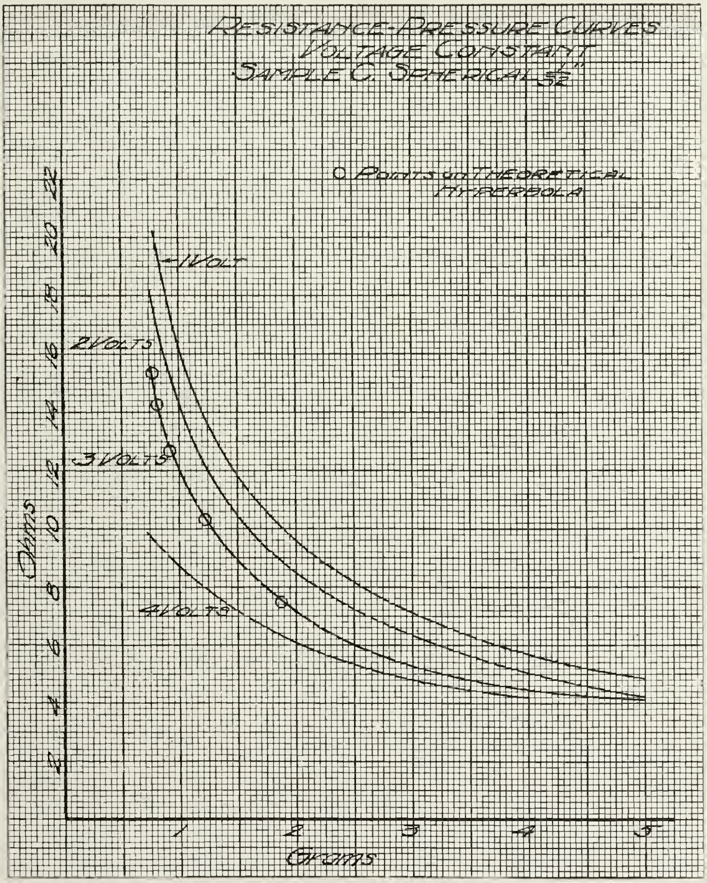


Fig. 5.

unless enough initial pressure is used to cause the particle to "follow up," the resistance will be increased, due to reduced area of actual contact surface. Above this critical value of voltage the entire point becomes heated and this more than offsets the increase of resistance at the point of actual contact. Below this critical voltage there is a balancing effect produced due to the increased resistance shutting off a portion of the current. The point upon cooling slightly tends to resume its former position, thus increasing again the current value. This accounts for the wavering action of the instruments at this point. Below this critical voltage the instruments are very unsteady.

From this data one may conclude that if perfectly smooth surfaces could be obtained there could be no change of resistance with pressure so long as actual contact existed. This is of course a practical impossibility. It might be remarked further that no doubt a magnification of 600 diameters fails to disclose all the peaks and points that affect the action, but on the whole it is the opinion of the writer that these irregularities acting upon each other, and influenced by both heat and pressure, give rise to microphonic phenomena.

In closing, the writer wishes to express his appreciation of the efforts of Messrs. E. B. Boar and F. A. Appenfelder, class of 1908, to perform successfully the experiments herein discussed, the greater part of the data herein given having been obtained by them pursuant to their thesis investigation under his direction.

THE CAPITOL AVENUE BRIDGE, INDIANAPOLIS, INDIANA,

LAWRENCE V. SHERIDAN, '09.

The new bridge crossing Fall Creek at Capitol Avenue in the City of Indianapolis was erected during the latter half of 1911 and the first half of 1912. This structure, consisting of three reinforced concrete arches faced with stone and granite, is notable in many of its features. Its location exerted a great influence upon the architectural features of its design, and made imperative a careful study of its final landscape setting. Capitol Avenue is the principal north and south boulevard of the city, and at the point where it crosses Fall Creek the greatest progress in the development of the extensive parkway system which has been planned for the city, has taken place. At this point parkways, with their attendant drives, have been constructed on either side of the stream and are rapidly assuming finished form, and it will be seen that the structure is in reality a Park bridge. This required a refinement of detail in its design that is not often considered necessary in the average structure.

The arches are the seven-center type, the center arch having a span of 84′ and a rise of 11.5′ while the end arches have spans 48′ and rises of 8.75′. Extending beyond the arches are approach walls with radii varying from 26′ to 50′, the radius of each wall being determined by the alignment of the curb connecting the curb on the bridge with that of the parkway drive. A slight camber carried from the ends of the approach over the entire structure adds greatly to the effect of solidity and massiveness which the whole structure has been designed to convey.

The site of the new bridge was occupied by an old steel structure, erected about 1876 and which had been in use until early in 1911. It consisted of two Pratt trusses with two roadways, each span consistinng of three trusses. The steel had become dangerously corroded. The foundations were composed of two limestone abutments and a concrete pier which had been built to replace a limestone pier which had been damaged during a flood. The abutments rested upon timber grillages made of rough hewn logs averaging about 15″x20″ in section, while the top plane of the grillage was at or possibly a little above the low water level and the timber was in fairly well preserved condition. There were three thicknesses of the timbers forming the grillage. This construction made the wrecking of the structure an easy task and it was accomplished in about three weeks time.

The contractors' plant was arranged as shown in Fig. 1. A temporary trestle, spanning the stream east of the bridge site and carrying a narrow gauge track, made the transfer of materials an easy matter. Any point of the structure could be reached with the derricks, the large one resting on the foundation of the old pier in the center of the stream having an 80′ boom, while one of the smaller derricks had a 55′ and the other a 60′ boom. They were all equipped with "bull-wheels" permitting a swing of almost 360°. This arrangement of the plant was very elastic and little time was lost in getting materials where they were needed quickly.

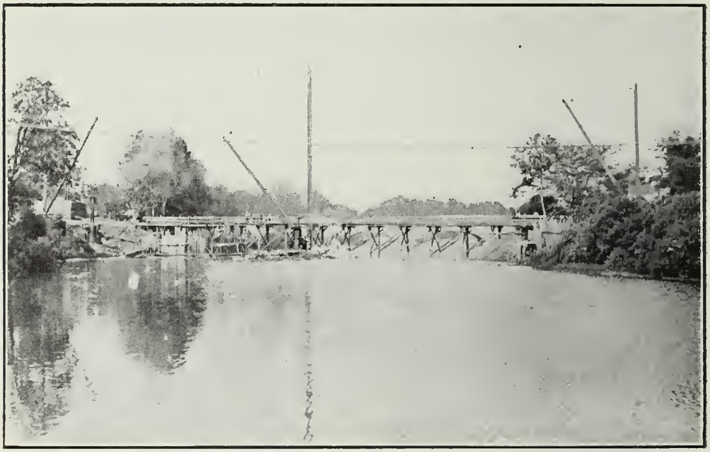


Fig. 1.

The excavation for the foundations was entirely through gravel. Coffer-dams built of 2″ sheeting were sunk with the aid of a single-line clam-shell bucket to points ten feet below the low water level, fifteen foot piles being then driven in this pit and spaced three feet center to center. They were driven with a No. 2 Vulcan steam hammer whose striking part weighed 3000 pounds and fell through a distance of 36″, the bearing values obtained by the application of the Wellington or Engineering News formula averaging about 7000 pounds, which was considerably higher than the values assigned in the design. It may be mentioned in this connection that no bearing value was assigned to the gravel in the design in order to provide for safety in case of excessive scour.

Some difficulty was experienced in pumping out the pits due to the porous structure of the bottoms which allowed the water to seep in with very little retardation. However, the water level was lowered to within a foot of the bottom with the aid of two 6″ and one 4″ centrifugal pumps, and this permitted of depositing the concrete with very little segregation of the materials. The concrete used for the substructure work was mixed in the proportions of one part cement, three parts sand and five parts of gravel, the gravel being obtained in excavating the pits. An examination of the natural mixture showed it to be nearer the proportion of one to one than three to five, and this condition was overcome by mixing in the proper amount of coarse material.

The concrete was deposited by the derricks from buckets in layers about 18″ thick up to a point two feet below the low water mark where it was leveled off to receive the first course of granite. The granite facing consisted of four courses averaging about 18″ in height and 10″ and 16″ in thickness in alternate courses to provide a bond with the concrete. They were also well anchored into the concrete with bent steel anchors. While the average pieces of granite did not weigh over a ton, the large caps for the starlings and the bases for the pylons weighed in the neighborhood of seven tons and required considerable care in handling and setting.

The centering, shown in Fig 2, required a great amount of care in its construction in order that no abrupt changes of curvature might be noticed in the finished arch ring. In order to obtain true templets for cutting the ribs, the curve of the arch was laid out on a large pattern board with the aid of a transit, stakes being set for each of the seven centers. After obtaining the true curve the templets were cut and checked, and were then used to mark the cutting lines on each rib, which was thus cut to the exact curvature desired. The centers were constructed on a very simple design. In the small arches three rows of piles were driven and in the large arch five were driven, the piles being spaced about six feet center to center. On these 12″ x 12″ caps were placed, upon which were laid hardwood wedges spaced 30″ apart in the small arches and 45″ in the large one. On the wedges a second cap composed of 3″ x 10″ pieces spiked together was placed and the stringers, 6″ x 10″ in the small arches and 8″ x 10″ in the larger one, were set on these caps directly over the wedges. Their ends were carefully beveled to fit tightly. The ribs, cut to the proper curve as mentioned above, were then placed on the stringers ready to receive the lagging which was composed of 2″ pieces over the flatter portions of the curve and of two thicknesses of 1″ pieces where the curve was sharper. When the load was applied very little deflection was noted, much less than would be expected from simple beams; however, the beams are rendered much stiffer by the arch action induced in the tightly fitting beams and also by the arching of the lagging.

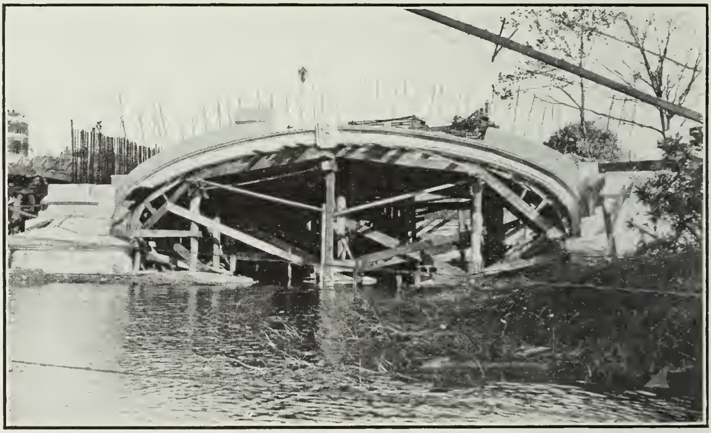


Fig. 2.

The Bedford stone was cut at the mills of the Bedford Cut Stone Company, and was laid out so perfectly that practically the only cutting necessary at the work was a slight trimming necessary to insert the keystones and the cutting of the grade at the first moulding. The stone was all set by one mason and a helper who easily kept ahead of the other work. The arrangement of the stone work is shown in Fig. 2. The stone was all cut very heavy, the architrave stones and the cornice being about three feet in thickness and none of the pieces being less than 8″ thick. This served to give a good bond with the concrete, but in addition each stone was anchored securely with steel anchors.

The arrangement of the steel is shown in Fig. 3. Square twisted bars with an elastic limit of 55000 pounds per sq. in. were used and were wired and braced securely in place. Fig. 3 shows the arrangement of the steeel in the approaches and also the forms of the sections. The buttress sections were used for the deeper portions of the wall and the cantilever where the height was not so great.

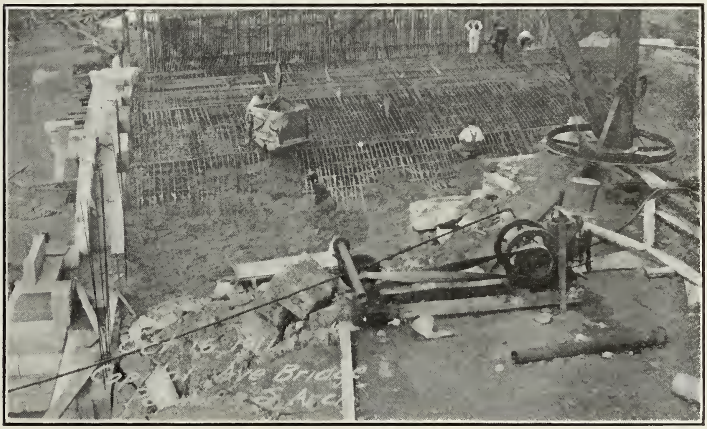


Fig. 3.

The concrete for the arches was in the proportion of one part cement, two parts sand and four parts broken stone (size 2½″). For the spandrel and approach walls the mixture was the same as for the substructure work (1:3:5). The arches were poured in longitudinal sections, the large arch being divided into four sections and the small ones in two. The spandrel and approach walls were poured in courses averaging two feet in depth in order to avoid pushing the stone out of place.

The problem of waterproofing was the most troublesome, and was not handled as successfully as was desired. A waterproofing compound was used to coat the surface of one small arch and the backs of portions of the spandrel and approach walls. On the large arch and one small one a "mineral rubber compound" was painted, two coats being given. This material was very highly recommended, and a series of tests were made to determine its waterproofing qualities. Several pieces of Bedford stone were given two coats of material, some being brushed on and others dipped; these pieces were then immersed in water colored with a scarlet dye. Upon breaking open those pieces which had been dipped a slight stain appeared, but the others were unstained. However, the arch coated with the waterproofing compound showed very little leakage, while those coated with the mineral rubber leaked considerably. This leakage is probably due to the lack of a sufficient bond between the material and the concrete. The stones were all backed with either LaFarge cement or the "mineral rubber," and all showed considerable cement stain, this probably being caused by the lack of bond between the "mineral rubber" and the stone in the one case and in the other case to the porous structure of the LaFarge mortar, which although absolutely stainless in itself allowed the soluble iron in the cement to pass through. It is possible that a mixture of three or four per cent of waterproofing compound with the non-staining cement might give good results.

The lighting system was designed to harmonize with the architecture of the bridge proper. The twelve lamp standards are of statuary bronze and each contains four 40 watt and one 60 watt Tungsten lamps. The system is controlled from a switch cabinet located in the post at the end of one of the approach walls, the standards being switched in pairs.

The sidewalks were constructed of 1:2:4 concrete surmounted by a 1:1½ wearing course containing No. 5 granite screenings. The surface of the walk is made with a float instead of a trowelled finish. The joints, however, are trowelled smooth on either side of the mark which serves to give a proper contrast to the sidewalk panels, which were laid out in such a manner as to emphasize the posts in the balustrade. The sidewalk serves as a cover plate for two conduits 2′ 6″ x 4′ 6″ in size. The total width of the walk is ten feet and the roadway, of Trinidad asphalt, is forty feet, giving a clear opening of sixty feet.

The total cost of the structure, including all extras which have been found to be necessary during the construction, will total $100,000.00, which, in view of the excellent manner in which the work was done, is a very low figure.

The bridge was built for Marion County, and the Board of Park Commissioners, of whom Dr. Henry Jameson is President, by the Cleary-Kuert Construction Company of Indianapolis after the design of George E. Kessler, Consulting Landscape Architect for the Park Board. Mr. Robert C. Barnett had charge of the engineering design and Mr. H. C. Broadwell was the architect for Mr. Kessler. The writer was the engineer in charge for the Park Board.

TOLL TELEPHONE TRAFFIC

R. S. Armstrong, '11

More and more as time passes business men are turning to the telephone to save them long journeys and the accompanying expense and time. Toll calls and Long Distance conversations are an every day occurrence. This increase in traffic over Toll lines has led to many discussions as to the best methods of handling this traffic; how the company can give quick, satisfactory, and economical service for as low a revenue as is consistent with the capital invested. In the limited space allowed it would be impossible to more than point out the essential factors of traffic work and what the young man entering this field can expect to encounter. It should be borne in mind by the reader that the remarks following apply to conditions in any large city having over 10,000 or 12,000 telephone subscribers and presenting questions and problems not encountered in the smaller telephone exchanges.

The Long Distance telephone traffic is naturally divided into two classes, long haul and short haul business. The long haul business is, as its name implies, that business which requires the use of long circuits and the accompanying characteristics of the same. This traffic usually is that requiring circuits over seventy-five to one hundred miles in length. The short haul business, on the other hand, consists of the traffic over circuits under seventy-five to one hundred miles in length, and is correspondingly heavier in the amount of traffic. This short haul business may be further sub-divided into the express service to the points nearest the city, say within a radius of nineteen miles, and the Toll service or that beyond this radius. The Chicago Express business is handled on what is known as a two-number basis; that is, the calling party gives his order to the recorder by number, the telephone company not guaranteeing to obtain an individual on these connections. Moreover the calling party holds his receiver until the connection is completed, the idea being to make this Express service as rapid as the local service and affording the cheapest service possible consistent with economic conditions. The Toll and long haul or Long Distance work is practically identical with the exception that with Toll work only about one per cent of the total traffic requires more than one circuit to complete the call, whereas with Long Distance work it is often necessary to use four, five, or six circuits. The operating instructions for handling Toll and Long Distance traffic are nearly identical although there are many minor differences due to the different character of the traffic. Hereafter in this paper the Toll and Long Distance work will be considered as identical.

Curve No. 1 shows a comparison of the speed of the service of the Express and Toll traffic handled in the Chicago Toll Room. These curves are plotted with the time interval in minutes as abscissae and the percentage of the calls completed as ordinates. It will be noted from these curves that in five minutes ninety-six per cent of the Express business is cared for while only sixty-eight per cent of the Toll business has been disposed of. This indicates the relative speed of the two classes of service.

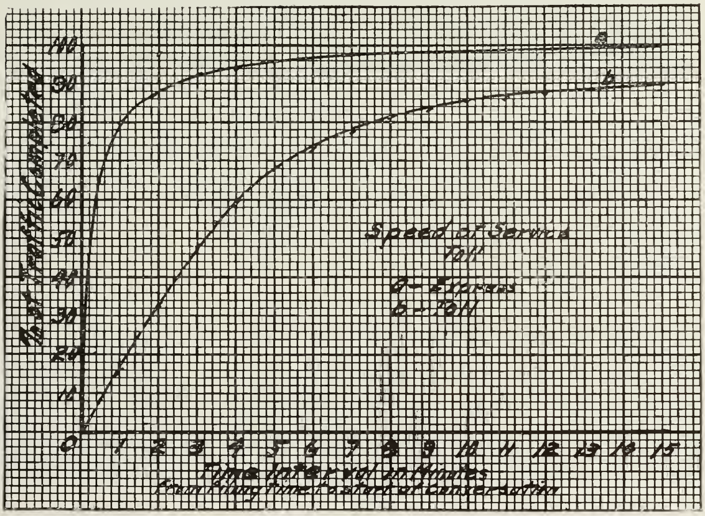


Fig. 1.

In the completion of any Long Distance call, there are four types of switchboard, and therefore four different operators involved, not including distributing operators and checkers mentioned later.

The "A" board in any office is the switchboard upon which the answering lamp and corresponding jack of the subscriber's line terminates. This lamp is located in front of an operator at the board so that she or the operator on either side of her can answer it readily. Generally speaking, only these three operators have access to this line.

The "B" board on the other hand is so arranged that any operator at the board can reach any subscriber's line in that particular office. The number of subscribers in any exchange is thus limited by the reach of the average operator. The modern exchanges of a large city are built to care for 10,500 subscribers.

In completing a local call the "A" operator answers the signal with the inside cord of an idle pair of the cords in front of her. Upon learning the number desired, she depresses the "call circuit" button to the office desired and tells the "B" operator the number wished. The "B" operator has a number of single cords before her which terminate in jacks at the originating "A" office. She selects an idle cord and passes the number of the cord to the "A" operator who immediately inserts the plug of the calling cord of her pair in the jack having the same number as the "B" operator's cord. The "B" operator in the

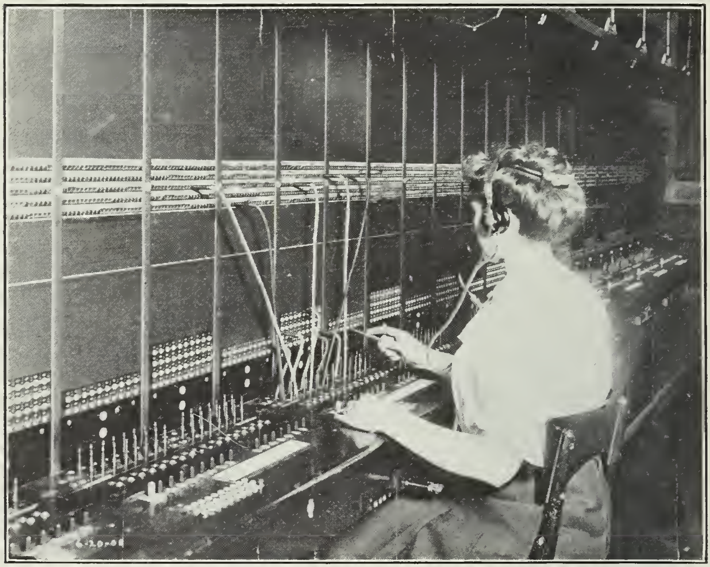


Fig. 2.
"A" Board

meantime inserts the plug of her cord in the jack of the subscriber's line called.

Plate No. 1 illustrates in a diagrammatic way an exchange system of two offices. "A" and "B" represent the "A" and "B" boards in "Main" office, and A′ and B′ the *A* and *B* boards in the "Central" office. *C* and *C′* represent one pair of the "A" operator's cords while *E* and *E′* represent the "B" operator's cords. *x* represents the answering light on each "A" board of the subscribers' lines *S* and *S′* respectively. It will be noted that these lines are bridged in each case to both the *A* and *B* board in the subscriber's office. Following a connection from *S* to *S′* from Plate No. 1; *S* picks up his receiver, causing the signal in front of the "Main" "A" operator to light. *A* answers with an inside cord and *S* asks for Central 294, *S′s* telephone. *A* closes her key, depresses the call circuit button (not shown) which connects her head set with that of the Central "B" operator, *B′*. "A" repeats the number desired to *B′* who picks up an idle cord (25) at the same time passing the number of this cord to *A*. *A* inserts the outside cord in the corresponding jack (25) of her lines to Central, while *B′* inserts her plug in the jack of the subscriber called.

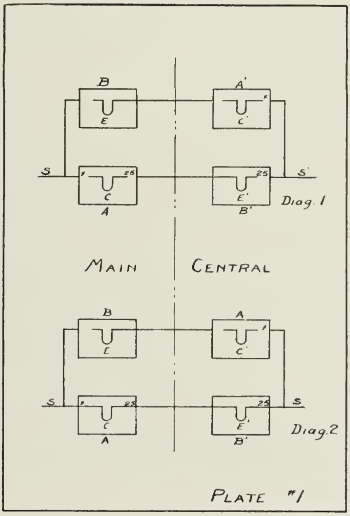


Fig. 3.

The ringing begins automatically on the modern boards, thus making it unnecessary for either the *A* or *B′* operator to ring the number manually. The cords are equipped with disconnect signals so that the operators will know when to take down the connection, and so that the "A" operator may be signalled in on to the connection at will by either subscriber.

When the subscriber *S* calls for Long Distance, the "A" operator answering his line places the calling cord of the pair she is using in any idle trunk to the recording board, thus automatically lighting a signal before the recording operator at the Long Distance office. The Long Distance recorder answers with an inside cord of her pair *C″* and takes the subscriber's order recording it on the ticket provided for this purpose. As soon as the details of the call have been secured the recorder requests the party to hang up his receiver, notifying him that the operator will call him. She, however, holds his line until she calls it back through the "B" board in the same way the "A" operator in the previous case called the telephone number of *S's* telephone. Since the recorder is holding the subscriber's line,

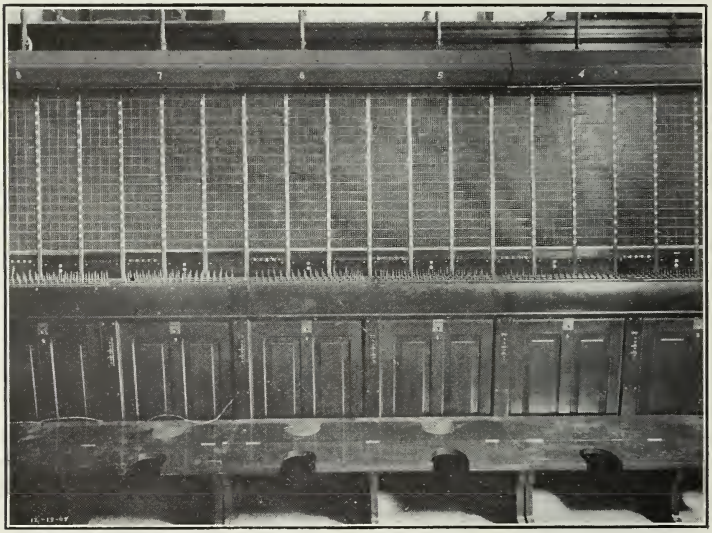


Fig. 4.
"B" Board

the "B" operator will get a busy test if she tests the line before completing the connection. In order that the connection may be put up, disregarding the busy test, the recorder informs the "B" operator by the word "without" that the call is to be completed without regard to the busy test. She places the number of the trunk on which the subscriber is being held on her ticket, so that when the line operator receives the ticket for the final completion of the call, she may pick up the same trunk in her multiple, thus causing a disconnect signal to fall before the recording operator notifying her that the line operator has picked up that trunk and that she may disconnect. The ticket is transmitted from the recording board to the line board in the larger Long Distance offices by means of pneumatic tubes. Each recording operator has access to a tube leading from her position to a distributing room. The distributing operator has before her a series of tubes leading to each section of line board so that she can distribute the tickets to any particular position along the line board. In this way a ticket is transferred in a very few seconds from the recorder to the line operator.

Plate No. 2, Diagram 1, shows the normal relation of the four types of board used in the completion of a Long Distance call; the "A" board (A), the "B" board (B), the recording board (Rec.) and the line board, respectively. Diagram No. 2 shows the subscriber *S* connected with the recording operator and the recording operator answering the line. Diagram No. 3 shows the relation of the offices after the recorder has called back the subscriber's number through the "B" board, thereby verifying the correctness of the number. Diagram No. 4 shows the relation of the offices when the connection has been completed through the line board to the toll line desired.

Needless to say the actual circuits in use are very complex and relatively sensitive. The diagramatic sketches in Plates Nos. 1 and 2, do not show any of the numerous relays, retarding coils, condensers, and the like, which make up the different circuits involved on the switchboards and the subscribers' lines. While this phase of the work is taken care of by the Maintenance Department, it is of vital interest to the traffic man, inasmuch as anything which tends to retard the work of the operators affects the rapidity of the service and increases the cost of furnishing the service. In case of storm trouble the traffic manager must necessarily be thoroughly acquainted with all Toll lines in order to devise emergency routings that the calls at hand may be completed readily with as little loss of revenue as possible.

On an Express call, as stated above, the subscriber holds his receiver until the call is completed. This requires a special type of board where the recorder will have access to the toll lines and be able to complete the call in the minimum length of time. The fundamental principle of recording and completing the call, however, is the same, with the exception that the recording operator completes the call. It may be stated that in the Chicago territory all the subscribers of the suburban towns have their names listed in the Chicago directory and the subscriber calls for a subscriber of one of these towns by the name of the town and the number of the telephone rather than by asking for Long Distance. The "A" operator has two sets of trunks, one marked Express and one marked Long Distance. It is necessary for her to recognize the express towns, when they are called for, and connect the calling party with the Express recorder.

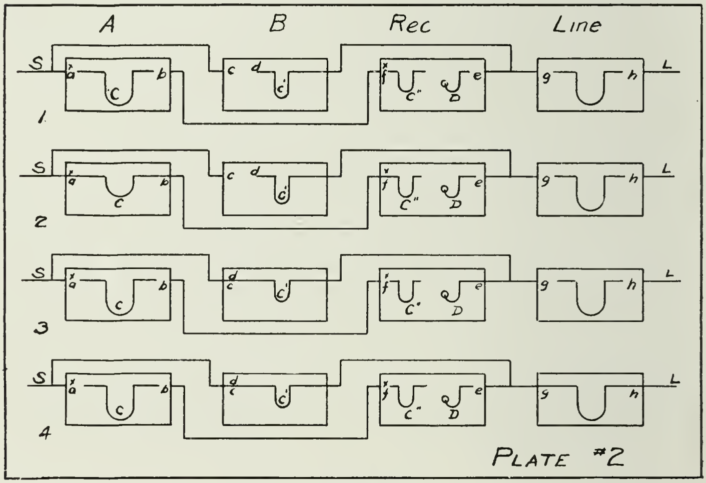


Fig. 5.

The growth of the number of telephones in service in the Chicago territory approximate 2500 a month. The calling rate (i. e., the number of Toll calls per telephone) remains approximately constant. This rapid growth necessitates a very careful estimate at the beginning of each year of the force for the coming year and careful revision of the figures from time to time to care for unusual conditions that might arise but which could not be foreseen.

The busy hours of the day are from nine to eleven o'clock in the morning. At noon the traffic falls off rapidly, picking up at two again and gradually decreasing until six p. m. Between seven and eight p. m. there is a slight peak and then follows a gradual decrease until eleven o'clock. While this particular summary covers the traffic of only one class of business, it is typical of all classes, local as well as Toll.

In considering the force necessary to handle any traffic, it is necessary to figure on the busy hour, for obviously if there are operators sufficient to handle the busy hour, the rest of the day will be cared for. It is common practice to work the operating forces in three shifts; day, evening and night. The day force is based upon the hour nine to ten a. m.; the evening on the hour seven to eight or six to seven, according to which is the busy hour, and the night force to care for 11-12 p. m. or 6-7 a. m. Each day operator is given one-half an hour relief, fifteen minutes in the morning and fifteen in the afternoon. The operators also get one-half an hour for lunch. An operator works only six days a week, hence it is necessary to arrange a day off for each operator working on a Sunday. The normal number of absentees must be accounted for as well as those on furlough and on vacations. After the force is figured this far it is necessary to estimate the number of probable resignations for the coming months and plan to employ students far enough in advance to cover these resignations. These few remarks will give the reader an idea of the factors entering into the consideration of the force.

A lengthy paper could be written dealing with the switchboard alone. Of special interest are the busy visuals used in connection with the Toll circuits. Each circuit is multiplied throughout the board. In order to save a few seconds time on the part of the operator each jack has associated with it a little white target which drops whenever that circuit is in use anywhere along the board. The operator can tell from this signal whether the line is busy or not without having to test the same with her plug. By means of transfer keys it is possible to throw all the answering lamp signals from the different boards into a few sections for night work thereby reducing the number of operators required. The system in use at Chicago is as flexible as one could wish, allowing the transfer of signals back and forth with little or no inconvenience.

Each set of cords has associated with it three keys, one ringing, one "split" key and a listening key. The ringing key throws the ringing current out on the inside cord when the key is pressed towards the board and out on the outside cord when pulled away from the board. The middle key, or "split" key, splits the cord circuit so that the operator can listen or talk on either cord independently of the other. The listening key when pressed towards the board, allows the operator to talk to the subscriber. When pulled away from the board she can listen but not talk. This latter provision is made so that the operator may supervise the connection without cutting down the transmission. Provision is made so that service supervisions may be made on any operator's board in the room. A regular "Service Supervision Department" cares for most of this work, although

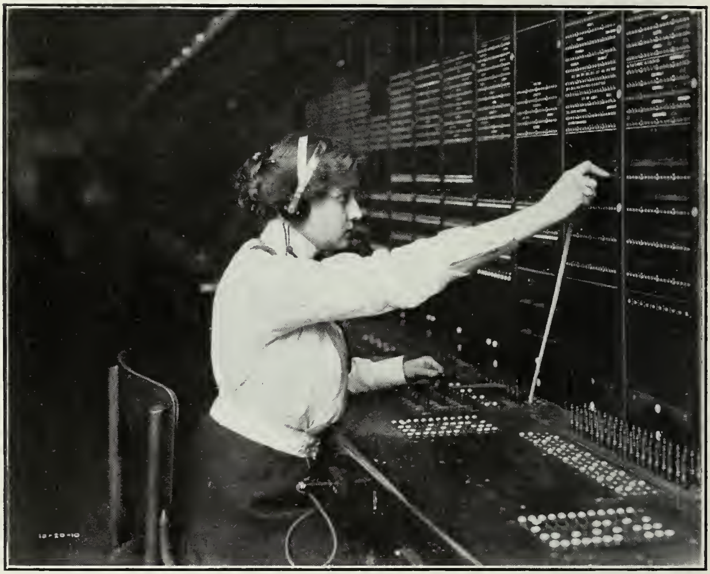


Fig. 6.
Toll Board

each office has its "Monitor," whose duty it is to listen to the work of different operators and criticise and help them as their work indicates they need it.

This paper has only roughly pointed out a few of the many problems in the daily routine of the Traffic Manager's work. It is a diverse work, bringing up many different phases continually; ever presenting new ideas. The Traffic Manager has to deal with all kinds of people, has to know how to "handle" his force and his subscribers. His work requires a clear mind, logical thought, a good idea of the fundamental principles of business in order that he may recognize and care for extraordinary and unusual conditions of all kinds. He must be a man who is broad-minded, ready to realize that his department *must* work in conjunction with the other departments and must co-operate with those with whom it has dealings. His work is growing daily; he must grow with it or drop behind. He must inspire confidence in his forces that they may know he will "be square" with them at all times and with his employers that they may know he is always "on the job" and that the best interest of the company is his interest. The telephone traffic manager's position is indeed one of the most diverse and at the same time interesting lines of work a young man could follow.

INDIANAPOLIS TRACK ELEVATION AESTHETIC DESIGN OF BRIDGES.

BENNETT KAMINSKY, '10

The difference in cost and trouble between an ugly structure and an attractive one is very little. In the present track elevation project, the site of which is in the heart of the city, it is certainly fitting that the structures should be of inviting appearance. An ugly bridge is something that cannot usually be remedied after once built. When the Indianapolis Southern gained entrance into the city several years ago, it was required to elevate its tracks within the city limits, but no restrictions were made as to the character of the bridges. As a result, a string of ugly through-plate-girder bridges have been saddled upon the southwestern part of the city.

The Indianapolis Union Railway Co. has made an earnest effort towards improving the appearance of its bridges. An architectural firm was retained to design the portal of the bridge over East Washington street. In this bridge (Fig. 1) the parapet extends from the clearance line to about three feet above the rail. The end columns are encased in concrete, monolithic with the parapet. In addition, a design of red and blue Moravian tile was worked into the concrete to relieve the color monotony. The whole gives a sturdy appearance together with a pleasing effect. On the other bridges mentioned above, one of which is illustrated herewith, Fig. 2, the columns are not encased, and there are no balustrades, giving the bridges a very flimsy appearance. In addition, they show the usual defect of concrete work—bad discoloration. The portals of the East Washington street bridge were constructed under a separate contract, and this work was done after the rest of the bridge was erected. The following is an extract from the specifications for this work:

> "The aggregate will be fine washed river gravel and must pass a screen of three meshes to the lineal inch and be held on a screen of four meshes to the lineal inch.....The proportions will be one part cement, two parts sand, and four parts gravel.....In order to secure a proper color con-

trast between the finished concrete and the Moravian tile and also to harmonize with the concrete abutments, gravel and sand will be selected of a warm buff color. After the forms have been removed, the exposed concrete surfaces will be finished by first rubbing down with emery bricks, so as to remove all form marks or other inequalities, and expose the aggregate. The surfaces will then be thoroughly washed down with hydrochloric acid diluted with water. The Moravian tile will be set in recesses left for them in the concrete after the surfaces of the concrete have been finished. The tile will be thoroughly moistened before setting and a mortar composed of one part sand and two parts Portland cement will be used for setting the tile. The sand must be sharp and clean, and must pass a screen of six meshes to the lineal inch."

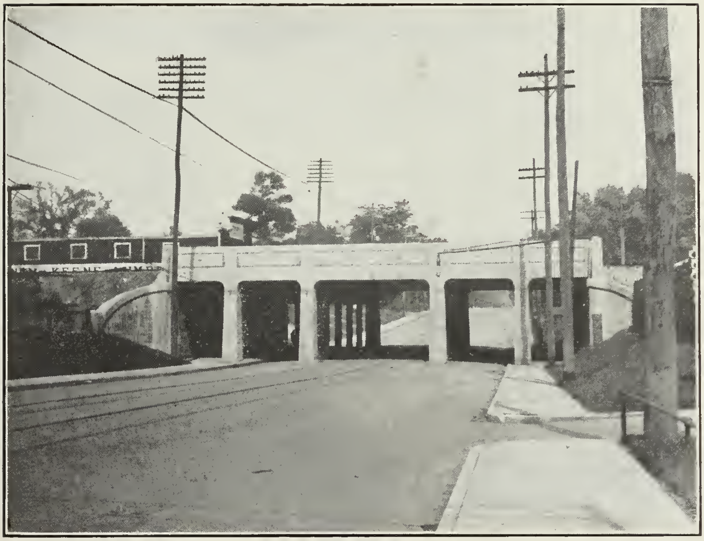


Fig. 1.
Washington Street Bridge.

An inspection of this bridge, or even the accompanying illustration, emphasizes the fact that favorable results can be obtained by the exercise of a little more than the ordinary care in concrete work. The abutments and wing walls are "railroad concrete"—just ordinary good 1:2:4 concrete with a rich mix on the face. Note the discoloration and the unevenness of surface. The portal, however, is free from such defects. The surface treatment seems to have given good results. The grinding-down process caused comparatively large and bright surfaces of the aggregate to be exposed, giving a granite-like effect.

The first consideration in aesthetic design, of course, is the type of bridge, and in this connection, there are some practical things to be observed. In the Indianapolis work, all of the bridges will be of the subway type, *i. e.,* tracks overhead and street underneath. A clear span is desirable but not necessary. A uniform clearance over the roadway but not necessarily including the sidewalks is desirable. The bridge *must* have a solid floor: (1) To prevent drippngs upon pedestrians, and (2) To eliminate noise and jarring sensation. Furthermore the type of bridge must permit of aesthetic treatment. For instance, a through truss bridge looks out of place at a crossing within the city limits. The types of bridges usually employed in city grade separation work are; (1) arches, (2) clear span, solid floor girder types, and (3) solid floor short span types, *i. e.,* with columns in the street.

For attractiveness, the arch has preference. An engineer will have to mistreat his arch design very severely before he will overcome its inherent qualities of attractiveness. Designers often desire to incorporate slightly arched effects in vertical reaction bridges, and often they metamorphose such a bridge entirely into an arch. Sometimes local conditions combined with a desire for an attractive bridge will excuse the practice of concealing the actual character of a structure. In grade separation work, for obvious reasons, it is always desirable to build a bridge in as short a time as possible. The arch takes longer than any other type of bridge to build. Besides, the centering for the arch obstructs highway traffic for a long time. On the other hand, a plate girder bridge can be erected and tracks thrown across it with remarkable celerity. If an arch effect is desired, it can be constructed later, with the steel work as a base. The Cleveland Short Line Ry. runs on an elevated grade through the residential part of that city. It was accordingly thought desirable to make the bridges over the various streets as attractive as possible. Highly satisfactory results were obtained by encasing the steel work in concrete and creating arched effects. The East Boulevard bridge appears to be a concrete arch but actually it is a plate girder structure. In the Indianapolis track elevation work, on account of the desire to obtain as great a clearance as possible, the arch or pseudo-arch is practically eliminated.

The chief advantage of the plate girder bridge lies in the fact that a clear span of uniform clearance can be obtained. On account of limited clearances, if plate girders are used anywhere at all, they must necessarily be through-girders. Wherever more than two tracks cross a bridge, at least three girders must be used, which will necessitate spreading the tracks apart over the bridge. Now if there is anything that the railroad engineer will go to extremes to avoid it is a jog in the alignment of his track. In the Indianapolis work, the bridges will be so close together that such "jogs" cannot be used, but on the other hand would call for a continuous excess spacing of the tracks, and this of course is out of the question. At none of the principal bridges in the Indianapolis work will there be less

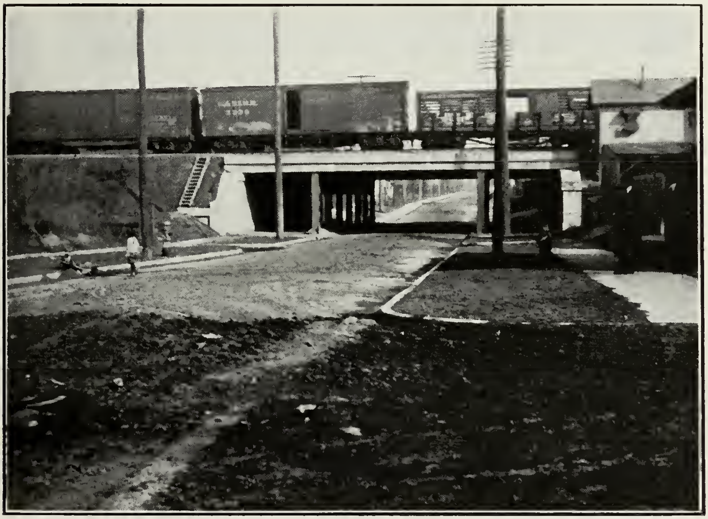


Fig. 2.

New York Street Bridge.

than four tracks, so, in view of what has just been said, the clear span plate girder bridge cannot be considered at all.

It is practically certain that nearly all of the bridges in the Indianapolis work will be of the solid trough floor type with columns in the street. It is also quite certain that the material used in the bridges will be steel and concrete. It is to be regretted that the railroads cannot find it possible to extend their liberality in construction work a little further and use for ornamental purposes some other material besides concrete. Stone is to be preferred by all means, as positive results can be assured with that material. With concrete, on the other hand, there is a great element of uncertainty to contend with. Having given the type of bridge and material, the problem will be to make the most of the situation.

In discussing the proposed Indianapolis track elevation bridges with interested people, the writer has encountered a remarkable divergence of opinion as to how concrete work can be made attractive. Apparently the only thing they agree on is that the surface of the concrete should be well broken up to give a light and shadow effect. As to other details, there seems to be a great variety in taste.

Regarding color, the writer has always had a preference for whitish concrete, the whiter, the better. A white concrete structure seems to enliven the surroundings, and if the material is properly mixed and poured, the danger of discoloration is reduced to a minimum. Many people apparently think differently. They want a concrete of a dull, dark color, or, "natural color of cement" as they term it. Still others desire an artificial coloring in concrete. In this connection, it might be of interest to refer to the tests made by the Pittsburg Bureau of Construction where brick dust was used instead of sand and gravel for aggregate. Excellent results are reported, the concrete having the appearance of red sandstone.

Surface finish also calls forth a variety of opinions. Either a tooled surface or a surface that is ground down after removal of forms seems to be desired by many. It adds about one to three per cent to the cost of the work, but when properly executed, even though it does nothing else but remove all inequalities due to forms, the extra cost is well worth while. In certain panels in the Larimer Ave. arch, Pittsburgh, Pa., the concrete was not spaded back from the face as is usually done, but on the contrary, large pebbles were allowed to come in contact with the forms. After the removal of the latter, the surface was bush-hammered, and in this process large sparkling surfaces of pebbles were exposed, giving a pleasing mosaic effects. The writer, however, has encountered a persistent prejudice against tooled or ground surfaces. In more than one instance a desire for concrete showing the board marks of the forms has been expressed. Such a surface is about as attractive as a board fence or the side of an unpainted barn.

The most interesting divergence of opinion is in regard to the use of colored tile, and the basis of all arguments is the East Washington street bridge previously discussed. The Moravian tile design was adopted at the personal instance of an eminent engineer and architect.

Many persons criticise the combination severely. In one instance the criticism of the bridge being: "It looks like a mud-house with pieces of colored glass stuck in it." No doubt some of the unfavorable comments were inspired by the cost of the tile. It is undoubtedly true that the use of the tile, even if the design is open to criticism, has proved effective in providing a color contrast and relieving the dull tone of the concrete. The universal fault with ordinary concrete work is its monotonous color, and the colored tile in the East Washington Street bridge, in spite of the criticism heaped upon it, has demonstrated its possibilities in future work.

A REVIEW OF ELECTRIC WELDING PROCESSES.

J. E. Teal, '09

The art of welding iron is probably as old as the earliest production of that metal by man, for in fact the reduction of iron demands the welding of the particles. Nearly pure iron is difficult to melt, but at high temperatures it becomes quite plastic. The black scale, iron oxide or iron rust, melts long before the metal itself becomes fluid. In the process of union, this scale is a convenient flux which may be squeezed out under pressure. These facts account for the unique position iron has held until recent years.

With the introduction of the electric current as the source of energy for supplying the heat, very few metals or alloys remain which cannot be welded. During recent years the extension of the application of electric welding has been steady, and each year has witnessed its entrance into new fields. In its simplest form, the necessary apparatus for electric welding consists of a special transformer, the primary circuit of which receives current at from one to five hundred volts. The secondary circuit consists of a single turn, generally, of a large cross-sectional area in order that a large current may be developed at a low voltage.

The electric welding system which permitted the most delicate adjustment and the highest speed and efficiency up to 1885 was that invented by Professor Elihu Thomson. The principle involved may be described as that of causing a heavy current to pass across the abutting ends of the metal to be welded, which action would develop heat at the point of contact on account of the high resistance offered to the flow of current. Mechanical pressure was applied to force the ends together while the current was flowing. As the parts of the metal at the junction became heated to the welding temperature, the pressure "followed up" the softening surface until a complete weld was obtained. As the heat was generated in the interior first, the interior of the parts was as efficiently welded as the visible surface. Professor Thomson's method differs from the so-called arc processes in that he employed the resistance of the metal as the means of generating the heat in place of using other resisting mediums.

The following examples serve to show the many applications of electric welding in the industries. In the wagon and carriage manufacture, the process is applied to the production of tires, axles, spoke bands, and sand bands. It finds extended use in manufacturing tools, in the wire industry, and in pipe bending and coiling. Hundreds of miles of street railway rails have been welded into continuous lengths. Longitudinal seams of steel tubing are electrically welded. The operation of welding hollow steel handles on cutlery by electricity is remarkable for the celerity and neatness of the work. Automatic electric welding machines have been perfected for the making of mesh wire fencing and link chains.

In the year 1892, the Johnson Company reorganized a department for the purpose of developing electric welding. In 1893, the company welded about fifty miles of street railway track under varying conditions, principally in the streets of Boston, Cleveland, Brooklyn, Johnstown, Detroit, and St. Louis. The following winter some breaks developed, which, upon investigation, were proved to have been caused by the poor condition of the track and by the overheating of the metal. During the years 1895, 1896, and 1897, more experiments were carried on and empirical laws were developed which were found to govern electric welding in such a manner that a homogeneous weld could be obtained without physical deterioration of the steel. Technically, attention was directed to uniformity of work, speed of work, use of minimum amount of current, and the removal of the minimum amount of material at the rail joints. Commercially, attention was directed to the reduction of cost of welding, and the securing of reliable results.

In comparing electric welding with forge fire welding, it is not necessary to bring the metal to a melting temperature with the electric process. The heat is applied from the inside instead of from the outside as with the forge. Also in using the electric current all the heat generated is applied to the metal, while only a part can be applied in the forge method. Non-ferrous metals can be welded as well as the iron products, whereas with the forge, it is possible to weld only iron and steel successfully.

The advantages of electric welding are numerous. The metal is visible at all times and can be watched while it is being heated. The temperature can be maintained at any point desired for any length of time, and any degree of heat can be obtained up to the melting point, so that the power is economically used. No fluxes are necessary, but may be judiciously used in some cases. The hotter the metal becomes the greater is its resistance to the flow of the current. Very little waste of the material is required in the upsetting of the metal. The center of the metal is as perfect as is the outside. The operator is in no danger from electric shock. Little time is required in making the weld. The process makes very little dust or smoke. The finished weld is nearly as homogeneous as the original metal. No fumes are given off. The process can be made automatic. Flaws in the material can be easily discovered. The process can be applied to many metals. Repair work can be done with great efficiency.

There are two electrical processes used in welding metals, namely, the arc and the resistance methods. The arc process is used extensively in repair work of all kinds. The resistance method is better adapted to industrial purposes and is embodied in all types of welding machines. Such machines have been made to work automatically, semi-automatically, by power, or by hand as the conditions required. Three types of welding are done by machines, namely, butt welding, spot welding, and lap welding. Butt welding machines are constructed to press the work together between jaws which form the electrical terminals. One of the two clamps is removable, and may be either automatic or hand operated. The jaws or clamps are shaped to conform with the work. Three to sixty seconds are required to bring the work up to the welding heat, and then the jaws are pressed together and the current switched off. The weld is made so quickly that the automatic trip for throwing out the switch is a much desired device for saving in current consumption. If the current is turned off too soon, the weld will break easily, and if not soon enough, a large fin will form around the work which necessitates extra work later.

The cost of making butt welds on round iron or steel from a quarter to two inches in diameter with the cost of current at five cents per kilowatt hour and including labor, is shown in the following table.

Round iron diameter in inches	Area sq. in.	Kw. used	Seconds to make weld	Cost per 1000 welds 5c per kw.
¼	0.5	5	5	$ 0.35
⅜	0.11	7½	6	0.65
½	0.20	8	10	1.10
⅝	0.31	10	12	1.65
¾	0.44	12	15	2.50
⅞	0.60	15	20	4.15
1	0.79	18	30	7.50
1⅛	0.99	20	30	8.30
1¼	1.23	26	40	14.45
1½	1.77	40	60	33.35
1¾	2.41	45	70	43.75
2	3.14	56	80	62.20

In spot welding, point shaped electrodes press the pieces of work together between them. Spot welding machines are generally used to weld full sections. They are designed chiefly to join sheets in spots as is done by rivets, and the electrodes are shaped in accordance with the special work that is to be done. Owing to the small travel of the electrodes, the machines are usually hand operated. Spot welding is very useful in replacing some classes of riveted work, as two or more thicknesses of metal can be fused together and be stronger than when riveted together. In an experiment, four spot welds withstood a pulling strain of 7800 pounds before breaking.

Seamless welding machines are employed where water tight joints are to be made. In this type of welding, the travel of the work is so slow that a continuous weld is made. The electrodes, as in the other machines, press the work together and effect the weld at the point of the greatest pressure. In lap welding, a revolving disc electrode passes over the seam to heat the metal to a welding heat, and at the same time presses the sheets together so that no shoulder or other imperfection is left. This process leaves the welded joint practically the same thickness as the original sheet and only an experienced person can detect the weld.

By the improved process of electric welding, the John Wood Manufacturing Company, of Conshohocken, Pa., turns out from eight hundred to one thousand bath boilers every twenty-four hours. Plates are rolled into cylindrical form, and passed through the sand blasting room where the scale is removed for about an inch and a half back on either side of the seam to be welded. Two modified Thomson welding machines are used. Current is furnished by two 60 kw. alternating current generators which deliver current to the primary circuit at from two hundred fifty to three hundred fifty volts. About one minute is required in passing the shell through the machine, and about twenty-two seconds for the actual welding.

The current used in the Thomson machines is a single phase alternating current of any frequency. The voltage is generally stepped down to from two to six volts, while the ampereage depends entirely upon the work to be performed. The current runs into thousands of amperes with some work, but the low voltage at the electrodes eliminates danger to the operator.

The following figures show the energy that is required for various work done by the Thomson machine:

ROUND STEEL RODS.

Diameter inches	Area sq. in.	H. P.	Time in seconds	H. P. seconds
¼	.05	2	10	20
⅓	.10	4.2	15	63
½	.22	6.5	20	130
⅝	.30	9.0	25	225
¾	.45	13.3	30	399

EXTRA HEAVY PIPING.

Inside diameter inches	Area sq. in.	H. P.	Time in seconds	H. P. seconds
½	.30	8.9	33	293.7
¾	.40	10.5	40	420.0
1	.60	16.4	47	770.8
1½	1.10	32.2	70	2261.0
2	1.65	42.0	84	3528.0
3	3.00	96.2	106	7197.0

The time and current used in welding copper and iron pipe are given in the following tables:

TIME AND CURRENT USED IN WELDING COPPER.

Area sq. in.	Time in seconds	Kw. transmitted
0.125	8	7.5
0.250	11	17.5
0.375	13	24.0
0.500	16	31.5
0.625	18	39.0
0.750	21	46.0
0.875	22	55.0
1.000	23	62.0

TIME AND CURRENT USED IN WELDING HEAVY IRON PIPE.

Inside dia. inches	Area sq. in.	Time in seconds	Kw. transmitted
½	0.30	33	7.2
¾	0.40	40	8.1
1	0.60	47	12.1
1¼	0.79	53	16.5
1½	1.10	70	24.3
2	1.65	84	31.5
2½	2.65	93	47.8
3	3.00	106	70.0

Numerous types of work and many different kinds of metals have been welded by electricity. Special appliances can be placed on all machines which will handle all shapes and sizes of work. The following list shows the various metals and combinations of metals which have been successfully welded by electricity:

PURE METALS.

Iron
Copper
Antimony
Lead
Bismuth
Manganese
Nickel
Tin
Silver
Magnesium
Cobalt
Gold
Aluminum
Platinum
Zinc

ALLOYS OF METALS.

All kinds of steel, brass, bronze, and aluminum; various grades of iron; gun metal; type metal; fuse metal; solder metal; and coin silver.

Combinations.

Copper to	Brass Iron Silver Gold	Wrought Iron to	Steel Brass Silver Nickel Cast Iron
Brass to	Iron Silver Tin Copper Steel Nickel	Gold to	Silver Platinum Nickel
Tin to	Zinc Brass Lead	Silver to	Platinum Copper Gold Brass Wrought Iron

Arc welding was used as far back as 1885. In this system the negative pole of a circuit carrying current capable of maintaining an arc was connected to a piece of work which required welding. The positive pole or terminal consisted of a carbon or metallic rod held in a suitable insulated handle. Arc welding is a process of fusion and is adapted to a variety of uses. The method has been greatly improved since its first introduction, and possesses some advantages over the resistance method in certain classes of repair work. However these advantages do not entirely compensate for the disadvantages. Much heat is lost by radiation; skilled operators are required; there is considerable danger to the workman; the process is slow and the results are uncertain. For satisfactory results, an arc of two or three inches in length must be maintained, and a current of 150 to 500 amperes at a voltage of 150 must be used.

The arc welding process may be divided into three classes. There are the Zerener, the Benardos, and the Slavianoss methods. In the Zerener process, an arc is first drawn between two carbons. By means of a magnet, the arc is directed upon the metal to be welded, which is brought to the fusing temperature at the point of contact with the arc. On account of the inefficiency of regulating the arc, and owing to the construction of the apparatus, this process is quite limited. In the Benardos process, the metal to be welded is made one terminal of a direct current. The other terminal is formed by a carbon or metallic rod. An arc is drawn between the terminals and a temperature of from 3500 to 4000 degrees Centigrade is obtained. If the metal is used as the negative electrode, only a short arc can be maintained, but by reversing the current, a longer arc is formed, and the carbon troubles affecting the hardness of the metal are largely eliminated. Operators are required to wear colored glass plates to protect their eyes on account of the brilliant arc rays. As the different welds require different strengths of current, a resistance control is used in the main circuit. A very good flux for wrought iron, cast iron, and malleable iron, and steel of all kinds, consists of a mixture of fifteen to twenty-five per cent of red oxide of iron ($Fe_2\ O_3$) and eighty-five to seventy-five per cent of borax ($Na_2\ Bo_4\ O_7$) ($H_2\ O$)$_5$. The theory is that the carbon from the carbon electrode will unite with the oxygen in the flux to form carbonic acid gas (CO), leaving pure iron. The borax tends to prevent oxidation by excluding the air. Material of the same kind which is to be welded is generally used as filler—scrap iron or filings. The following precautions should be taken in making a weld by the Benardos process: The positive terminal should be fastened to the metal; the arc should be as long as possible; the weld should be made with the fewest applications of the arc; the arc should be given a rotary motion by the hand; the metal to be welded should be free from dirt and slag; and a suitable flux should be used judiciously.

The Slavianoss process uses the metal electrode instead of the carbon, and is, in general, the same as the Benardos. For welding iron and steel, the electrode should be the best grade of soft iron from three-sixteenths to one-quarter of an inch in diameter, and should be covered with a suitable paste of flux. A flux used by the Westinghouse Electric Company gives good results. It consists of five per cent of oxide of copper ($Cu\ O$), fifteen per cent of manganese oxide ($Mn\ O_2$), thirty per cent of oxide of iron ($Fe_2\ O_3$), and fifty per cent of borax ($Na_2\ Bo_4\ O_7$) ($H_2\ O$)$_5$. A direct current of about one hundred thirty amperes at twenty-four to twenty-six volts directly across the arcs is found to give the best results with this process.

A MODERN HYDRO ELECTRIC PLANT.

M. H. Frank, '12.

The Hydro-electric plant that is being installed in the St. Joe River at Elkhart, Indiana, is generally accepted as embodying the very latest ideas and principles in reinforced concrete dams and power houses and in generating equipment.

The dam is of the Tainter gate type 300 feet wide, made up of eleven gates, as shown below, each 25 feet wide and allowing 2.5 feet for each of the 10 piers which support the gates and runway.

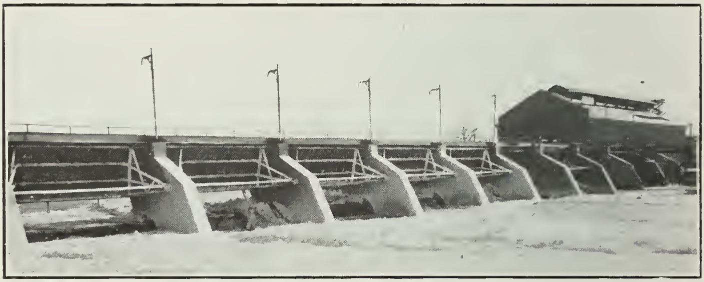


Fig. 1.

Tainter Gate Dam Power House to Right.

As can be seen in cut the gates are parts of perfect metal cylinders and revolve about their own centers. They are operated by means of an electric crab on the overhead runway. By means of these gates it is possible to hold the headwater to within twelve inches variation the year around. As there is 8.5 feet of water over the weirs on which the gates rest when down it will be necessary in time of low water to have the gates dropped clear down, thus making all of the water pass through the power house, while in time of flood or high water all the gates may be raised entirely up, thus allowing a section 275'x8.5' to carry the water not taken through the power house. This will take care of a flood much larger than has ever been recorded. As the gates revolve about their own centers, the friction loss is very small and a 5 H. P. motor will raise a gate 10 feet in 20 minutes. In order to be able to operate the gates in freezing weather steam chambers are provided for the three center gates, both on the piers and on the gates. When it is desired to raise or lower a gate live steam is turned into the chambers from the heating plant in the power house.

The power house is on the left side of the dam, the last pier for the dam being extended upstream to form one wall of the power house and penstocks and downstream to form the tail race wall. The building is constructed of reinforced concrete throughout to about 5 feet above the water line, then finished with red hydraulic brick and roofed with cinder concrete covered with green tile.

Three 22 foot and one 10 foot exciter penstocks are separated by 2.5 foot walls, these penstocks are equipped with Tainter gates and are the first ever constructed. The advantage is that in case of any trouble with the turbines or governor all that is necessary is to lower the gate, open a drain valve and in a few minutes the penstock will be a dry room. These gates are operated by an electric crab the same as on the dam, the gates being a little narrower but higher, holding a 16 foot lead.

A horizontal line-shaft lengthwise of each penstock driven by two tandem 50-inch Samson turbines, passes through the back wall of the penstock and is direct connected to the generator. The two draft tubes were built with the centers on line of the shaft at the top but the front elbow is turned slightly to the right, and back or downstream elbow slightly to the left, so that they enter the tailrace parallel separated by a two foot wall. A smooth surface on the concrete and the proper increase in size to lower friction loss and velocity respectively was obtained by building wooden sections, then lathing the sections. thus forming a perfect elbow. These were placed in exact position, plastered and enameled, then the concrete was carefully placed around them, and the result is a very smooth surface of exact size.

The generating equipment consists of 3 1000 K. W., 4000 volt, 60 cycle, 120 R. P. M. alternators and a 100 K. W., 125 volt, 250 R. P. M. D. C. generator in the exciter or 10 foot penstock. These generators are furnished by the Westinghouse Electric Co. but installed by the operating company.

Complete plans are made to run a very elaborate and accurate test on the entire plant as soon as it is put into operation. A testing weir is being constructed across the tailrace about 175 feet below the power house for this purpose. The weir is made of timber gates covered with canvas and supported by "H" columns set in concrete. By means of this weir the exact amount of water passing through the wheels may be obtained. This data, together with the output from the generators, will give the efficiency,

Throughout the construction the main object has been to have a permanent structure with a very high efficiency, and there is no doubt but that this plant will be one of the most efficient as well as one of the most modern plants in operation.

DISINFECTION OF PUBLIC WATER SUPPLIES

C. A. Jennings, '06.

The disinfection of public water supplies by means of hypochlorite of lime (chloride of lime or bleaching powder) came into general use during the summer of 1908. The enormity of the water purification problem attached at the Bubbly Creek filter plant at the Chicago Stock yards, is really responsible for its general application to water purification. At this plant a dilute sewage was used as the raw water supply. Copper sulphate did not handle the water successfully and upon the recommendation of Mr. Geo. A. Johnson, of New York, hypochlorite was given a thorough trial. The results were remarkable from the beginning. Quickly following its use at the Bubbly Creek plant, it was used at Jersey City and Little Falls, N. J.

The treatment with hypochlorite consists essentially of the introduction into the water of a solution of hypochlorite of lime, usually referred to as "hypo," having a strength of about one-half per cent. The strength of the solution, the amount applied, the method and point of application, the time period of contact and many other features, will vary under the different conditions met with at various cities.

At most filter plants, the hypo is now added just previous to filtration so as to take advantage of as long a period of sedimentation as possible and to reduce the organic matter and bacteria, also to increase the time period of contact and so insure the complete decomposition of the hypo before the water reaches the consumer. Any undecomposed hypo, although not injurious to the health, will impart to the water a characteristic taste and odor. Many cities that are using the hypo treatment today have no complaints of odor or taste.

It is essential that the treatment be properly and scientifically designed and carefully operated. Synchonous chemical solution pumps are used in a number of places. These proportion the amount of hypo applied to the pumpage. This method of application is particularly adaptable to plants having a system of direct pumping into the main with a consequent large variation in the speed of the high duty pumps. The synchronous pump has been used only in connection with reciprocating engines, and none have been designed to operate synchronously with centrifugal pumps.

The amount of chemical used varies from about three pounds to sixty or seventy pounds per million gallons of water treated. The quantity used depends upon the amount of oxidizable organic matter present. At any one plant the quantity needed is not constant but varies from day to day. In some cities, notably those using water from the Great Lakes, it has been found that the dose of hypo can be gauged fairly accurately from the turbidity of the lake water. With river and well water this will not hold true.

Hypochlorite is used to disinfect water supplies of all types, viz: water from shallow and deep wells, from mountains streams, from impounding reservoirs, from lakes and from rivers. It is used alone in some cases; in others it is used in conjunction with storage, with plain sedimentation, with slow sand pressure, and rapid sand filtration. Filtration will remove about 97 per cent of the total bacteria present in the ordinary water supply without any particular selective action. With hypochlorite as an adjunct, the efficiency can be increased to 98.5 per cent and even as high as 99.9 per cent. Furthermore, it exerts the selective action and kills the bacteria of color type and therefore, we believe, the germs of typhoid fever.

So efficient has been the hypochlorite treatment that the practice is now to immediately install temporary disinfection with hypo whenever there is any suspicion of the water supply. At least four state boards of health have portable treatment plants which can be shipped to any part of the state on short notice, assembled and be ready for operation within a day or two. To build a filter plant would require twelve months or more. Almost invariably, hypochlorite treatment is recommended for immediate installation when any epidemilogist makes an investigation of the source of typhoid fever infection during an epidemic of this disease.

Besides being a very effective preventative against water-born typhoid fever, hypochlorite treatment is very cheap to install and operate. A temporary installation of wooden tanks will cost from about $200 up, depending upon the size of the installation and local conditions. A permanent treatment plant of concrete tanks will cost from $700 upwards. A temporary installation made by the writer for a water supply of 3,000,000 gallons daily, cost about $350, including consulting fees. A permanent plant to treat 20,000,000 gallons daily, installed by the writer, cost about $5,000. This included a frame building, 12 x 24 x 20, containing the tanks, orifice boxes, a storage room and laboratory, as well as the laboratory equipment and consulting expert's fee. The chemical itself costs 1⅓ cents per pound in large containers, in carload quantities. A fair figure for the average user would be about 2 cents per pound. The average quantity used is about 6 or 8 pounds per million gallons of water used. This would make the cost of treatment come to about 12 or 16 cents per million gallons. The additional labor involved is very slight and in the average size plant, it does not amount to much on the basis of one million gallons treated.

During 1912 Cleveland, Ohio, had the lowest typhoid fever death rate of any of the larger American cities. It was 5.9 per 100,000 population. This is considerably less than during previous years, when hypochlorite was not being used. In 1911 the rate was 14.7 with hypochlorite in use during the last 3½ months of the year. Erie, Pa., had a typhoid fever death rate of 8.7 per 100,000 for the year 1912. Previous years were as follows:

Year	Typhoid fever death rate per 100,000
1900	34.0
1901	14.8
1902	23.4
1903	29.9
1904	46.4
1905	18.4
1906	47.5
1907	78.5
1908	61.1
1909	29.1
1910	39.1
1911	197.0
1912	8.7

This is certainly a remarkable reduction in typhoid fever. What is true of Cleveland and Erie, is also true of many other cities.

Hypochlorite treatment will not make water clear; it will not remove color except to a slight degree; it will not remove tastes from the water; it cannot be relied upon to remove odors; and it cannot be universally applied to kill algae, as it will kill some but not others. However, hypochlorite will kill disease producing germs in the water and as a germicide, it is effective, cheap, certain and rapid in its action. This treatment will continue to find wider application in the protection and disinfection of water supplies as it well deserves. Among the larger cities now using hypochlorite to disinfect the water supply might be mentioned New York, Philadelphia, Pittsburg, Chicago, Cleveland, Cincinnati, St. Louis, Minneapolis, Baltimore, Columbus, Indianapolis, Denver, Kansas City, Nashville. The writer has a list of 200 cities using this treatment, which list is probably not more than one-half or one-third complete.

THE RECLAMATION OF PERIODICALLY OVERFLOWED LANDS

FRED F. SHAFER, C. E., '11

Periodically overflowed lands may be defined as the bottom lands along streams, which are subject to overflow at various times in the year, and upon which the crops are destroyed from time to time. It may be that a great part of this land is subject to cultivation when overflows do not occur. The continually increasing value of this land is directing attention to its complete reclamation.

There are many important considerations from the practical and engineering point of view, in planning improvements that will prevent the overflows, and perhaps afford direct drainage to considerable areas that may be too wet for profitable cultivation, even if overflows do not occur. The main consideration is to provide adequate protection and direct drainage to the bottom lands at a reasonable cost. It is characteristic of all such land that it lies in long, narrow valleys and the area overflowed is roughly proportional to the size of the watershed.

The following table compiled from surveys made by Drainage Investigations of the U. S. Department of Agriculture, of numerous overflowed bottom lands in various parts of the United States, shows the relations referred to above.

TABLE OF WATERSHEDS AND OVERFLOWED AREAS

State	Name of Stream	Area of Watershed in sq. miles	Overflowed area in square miles	Per cent of Overflowed land
Kansas	Neosho River	5,090	253	4.9
"	Cottonwood	1,925	88	4.6
"	Marias de Cygnes	3,360	124	3.7
Nebraska	Nemaha River	375	21	5.6
Oklahoma	Deep Fork Canadian	900	42	4.7
Missouri	Locust Creek	653	32	4.9
"	Saline Creek	277	10	3.6
Iowa	Des Moines R	2,720	44	1.6

The average proportion of the area overflowed of the watershed is approximately 4.2 per cent. This does not imply that there are not other overflowed lands which could be improved, but the data refers to the overflowed lands that can be improved, profitably, at the present time. As the value of farm crops increase, there will also be an increase in the area of lands that may be reclaimed for agricultural uses.

PREVALENCE OF FLOODS

It has been the writer's duty to have examined a large number of streams in the middle west and to have collected data on rainfall and floods on these particular streams. The information obtained seems to show that floods are increasing, in severity and frequency, on the smaller streams. This data has been secured in many cases by actual measurements of the high water marks, and by general data on the duration and periods of the floods.

There are certain fundamental reasons why floods should be increasing. The agencies responsible for this increase are found in the natural growth of the country and the existing methods of cultivation. The U. S. Weather Bureau authorities state that the rainfall, so far as it has been recorded, does not show a progressive change in any part of the country. Other factors remaining the same then, the amount of water appearing in the channels of the streams as run-off would not be any greater than formerly. Examine any stream in the middle west, or any other part of the country, for that matter, and what may be seen? There are accumulations of logs, brush, stumps, sand bars, low bridges, mill dams and all manner of debris imaginable. Ditches have been constructed that drain low points, or former lakes, and they now discharge the rain fall into the main channel in a few hours after a storm, where formerly these ponds and lakes retained the water until it evaporated. It is probable that some of these agencies affecting the flow of water existed before the advent of the white settler, but his coming and the work that he has done has greatly added to the deteriorating factors in the streams. The timber has been cut for the lumber or posts that it afforded, the brush and stumps have been left to the next freshet to carry away, which means ultimately, that any floatable object finds a resting place in the channel. The upland has been broken for farming purposes. It washes easily and the sediment is carried to the channel to form bars which obstruct the flow of the water.

Many of the valleys of the western states were subject to fires which kept them pretty well devastated of the timber, and since the cessation of these fires the timber has been allowed to grow whenever it was not needed for the settlers. The timber in itself is probably the greatest deterrent factor to the carrying capacity of the streams. After periods of high water one may pass along any stream of the west where there is standing timber and see strips of the banks, which have been loosened by the swaying action of the trees, and the soaking of the water so that the earth slides bodily into the channel, carrying with it the trees. Many times the trees remain standing in an upright position and continue to grow, in other instances they fall into the channel. This action modifies the cross-section of the stream and serves to obstruct the flow. Is it any wonder that the channels are crooked and that they overflow?

LENGTH OF CHANNELS

The streams without exception are very tortuous and crooked in their course. They are continually changing; long bends are occasionally cut across, leaving a bayou or lake; other bends are becoming longer, so that in any one stream it is not probable that the length of the stream is changing perceptably.

The following table has been prepared from surveys made by Drainage Investigations of the U. S. Department of Agriculture, and illustrates some general characteristics of the channels of the western streams:

TABLE ILLUSTRATING THE LENGTH OF STREAMS AND THE AVERAGE FALL IN THE VALLEY

State	Stream	LENGTH, MILES		Ratio of meandered length to an air line	AVERAGE FALL FT. PER MILE.	
		By Meander	By Air Line		By River	By air line
Kansas	Cottonwood	120.0	62.0	1.94	1.89	3.66
“	Marias de Cygnes	138.0	88.0	1.57	1.43	2.24
Nebraska	Salt Creek	78.0	36.0	2.17	1.78	3.86
“	Nemaha R.	42.4	24.9	1.70	3.07	5.22
“	Elkhorn R.	21.8	13.6	1.60	3.89	6.25
Oklahoma	Deep Fork	62.0	41.0	1.51	2.90	1.90
Iowa	Des Moines	68.0	37.0	1.84	1.54	2.84
“	Big Sioux	36.6	17.0	2.15	1.37	2.94
*Missouri	Locust Cr.	59.0	25.0	2.36	1.59	3.76
* “	Saline Cr.	38.0	18.5	2.04	1.47	3.00

*Preliminary examination only.

The above table explodes a popular fallacy in regard to the relation of the length of a stream to the length of the valley. The laymen will usually contend that the stream is the "crookedest one in the country" and that "it is five times as far by it as it is down the valley." One cannot depend upon local authority for the truth in regard to the length of streams.

FACTORS AFFECTING RUN-OFF

The factors that affect the amount of water contributed from the watershed to the natural drainage channels may be enumerated briefly as follows: rainfall, topography, soil, size of and shape of the watershed, number and distribution of the natural drainage channels and number and character of the natural storage basins. The term, run-off, refers, not to the monthly or annual, but to the maximum discharge from a watershed after a single heavy storm of perhaps only a few hours duration, or possible three or four days duration. Run-off may be measured in cubic feet per second flowing in a channel, or it may refer to the withdrawing of water of a certain depth in inches from a watershed in twenty-four hours; in the latter case it is sometimes termed the "drainage coefficient." For land reclamation, the time in which the surplus water is to be withdrawn is usually taken as twenty-four hours. Practically any farm crop can stand in water for twenty-four hours without suffering damage. Some crops could stand two or three days without damage, but that depends largely upon the state of the weather at the time. One inch in depth removed from an area of one square mile in twenty-four hours would produce a uniform flow in a channel of 26.89 cubic feet per second and to remove water from a watershed of 100 square miles in extent at a rate of one inch in twenty-four hours would require a carrying capacity of 2,689 cubic feet per second.

A study should be made of the rainfall records for stations within or near the watershed of the stream under consideration. A table should be prepared, which will show the dates, rates, and frequency of excessive precipitations that may have caused overflows. This table should include rain storms of two inches and over, falling within twenty-four hours; rainfalls of less than two inches in twenty-four hours rarely do much damage, unless preceded by frequent heavy rains. Very high waters may be caused in the winter or early spring by small rains, but overflows occurring at this season of the year do not damage crops, but may cause considerable inconvenience and damage to personal property.

It is highly essential that the watershed be studied, in order that the area may be classified as flat, rolling, rough, stony, or very rough and stony. Areas that are flat show a much smaller rate of maximum run-off than a similar area which is rolling or gently undulating. The run-off increases rapidly with an increase in the roughness of the surface conditions, other factors remaining the same. The soil is a great factor in distributing the run-off, as the pore space, or capacity for water, varies greatly with the soil. A fine grained soil, such as an alluvial clay, has a much greater pore space than a sandy loam or gravelly soil. A fine soil does not permit of ready percolation of the water through it, while a sandy or gravelly soil does permit ready movement of the water between its particles. A rolling sandy soil would no doubt show a lower rate of run-off than a flat, fine clay soil.

The size of the watershed is, of course, a very important consideration, for the greater the watershed the greater the total discharge, but the smaller the watershed the less the run-off per unit of area. In a large watershed the flood will usually last longer than in a small watershed, but the rise of the flood water is not so rapid. The shape of the contributing area is perhaps of as much importance as the area. A long, narrow area will not produce as severe a flood, or one of so long duration as an area more rectangular or triangular. The distribution of the minor tributaries or other streams is also a governing factor in the run-off. If it were possible to arrange these tributaries so that no two of them discharged into the main channel near the same point, the floods could be lessened. A fan-shaped area, with the tributaries all about the same length and discharging near the same point, furnishes an ideal condition for high waters and for sudden concentration of floods.

The last factor affecting run-off is that of the natural storage basins, or reservoirs. Examples of this character of watershed may be found in Minnesota, Iowa, and northern Indiana. In these instances there are numerous small lakes and marshes whose area is an appreciable part of the entire watershed. They will exert more influence on the run-off during the summer months than in the early spring or winter. Evaporation during the warm weather will cause the water surfaces to lower and thereby provide a considerable storage capacity. In northern Missouri and southern Iowa, farmers have frequently made small reservoirs in low places where they will catch the run-off for stock. The areas thus enclosed are small, and will probably not affect the maximum run-off. The principal advantage of these storage basins is that it serves to collect the sediment that would otherwise be carried away.

The character of the vegetation of the watershed, as far as we have any direct knowledge of it, has no appreciable effect on the run-off. A timbered area would not have so high a rate of maximum discharge as an untimbered area, but the discharge would be distributed over a longer time. A drainage system must be designed so that it will be efficient when the area is under a high state of cultivation.

ENGINEERING DATA REQUIRED

Thus far there have been considered only the general factors that can be determined by a careful inspection of the district. This data needs to be supplemented by a certain amount of instrument work and other observations. The greatest need in any proposed district would be to know with some degree of accuracy the amount of flood water that will have to be provided for. It is a notable and deplorable fact that so little information of this character exists. A series of current meter measurements extending over a period of ten or fifteen years would furnish all of the information desired if such could be obtained. It is hoped that the States will in time realize this necessity and provide in some way for the taking of measurements.

Extensive surveys should be made in any district and they should show a careful meander of the natural drainage channels with frequent cross-sections which will assist in determining their capacity; and the location, by meanders and levels, of the boundary of the flooded lands, or lands needing drainage. Level lines should be extended across the valley at frequent intervals, the frequency of which depend upon the size of the district. They should not be farther than two miles apart and probably not closer than half a mile. High water marks with their dates of occurrence should be obtained whenever possible as well as soil borings to determine the character of material to be encountered in the construction, and lastly, trial lines for the proposed improvements should be run in order to furnish a more dependable basis for estimating quantities.

All of the indicated work can be done easily and rapidly by the use of standard surveying instruments equipped with stadia and magnetic needles. It is advisable to secure copies of the U. S. Land Office plats of the townships. Copies of these maps may be drawn to any convenient scale and the field work platted on the new maps. In this way the data can be checked and corrected to correct maps. It is necessary that frequent checks be made in the survey on land lines and corners. Located lines for the improvements should be measured with a good chain or tape, and the stations set at 100 foot intervals. These lines should be so located that they can be retraced by other engineers at any time. This will necessitate carrying azimuth or deflection angles, and marking or locating the deflection points carefully.

FORMS OF IMPROVEMENTS

The guiding factor in such improvements will always be the final cost. In so many cases that the writer has examined the cost for adequate improvements would be greater than the land-owners felt willing to pay. The plans are usually modified to meet a lower cost than the merits of the work deserve. The cost of improvements for the periodically overflowed lands will always be greater than for the swampy lands of the south. The average cost for this class of work as now being done is about twelve to twenty dollars per acre.

It will be the engineer's duty to determine the plans that will furnish the required efficiency, and then to try to persuade the land-owners that his plans should be adopted. Failing in this he will have to submit several plans and permit the land-owners to choose the one that will give the best results at the lowest cost. It should be his duty to arrange the plans so that subsequent work may be done without material alteration in the original work. There are five general plans or forms of improvement for the protection of bottom lands from overflow; each one has its advantages and disadvantages. More than one form may be required in any one district, so that an engineer can exercise some real ability and ingenuity. The Relief Ditch, so called because it is designed to relieve the existing channel in times of high water, is the form of improvement most frequently used in overflowed bottom lands. In this case the engineers will be required to locate this ditch to the best advantage and to design it so that, together with the old channel, adequate capacity will be provided for the run-off assumed. The location of such a ditch will prove a difficult matter, not because of the engineering phases, but because nine out of every ten land-owners will assume that they can locate the ditch "just where it ought to go" and will insist on this prerogative.

It is a general characteristic of all bottom land streams that they have built-up banks which may be from two to four feet higher than the bottoms near the limiting bluffs. With this fact in mind, it is obvious that the relief ditch should not be located near the present channel; it should be located as far as possible in the lowest ground in the valley, which will not only provide a relief to the old channel, but will also afford direct drainage to the lowest lands. There are three reasons why a relief channel should avoid following the existing stream. First, the new channel is to act in relief and to be efficient the two channels should avoid crossing; second, since the stream banks are always built up higher than the remainder of the bottoms, it will require greater excavation to make a channel of given capacity at a minimum cost if located near the existing channel; third, the thread of the overflow will always follow the lowest ground, and to afford relief, the new channel should be located where the flood waters are to be found. It will not always be possible to avoid occasional crossings with the old channel and when this is necessary provision must be made at such crossing for the combined capacities of the two channels.

A second form of government for protection from overflow would be a levee system. It is unfortunate but true that land-owners are prejudiced against levee systems. They have heard how levees have failed in critical times and they imagine that levees always fail. They do not consider the circumstances fully and are not usually informed of all of the facts. The principal cause of levee failures is that they have not been built sufficiently strong. We know much more about the construction of levees than we did fifteen or twenty years ago, and such structures that are now built do not fail so readily. The choice between a levee system and a relief ditch must be determined by the cost, both initial and of maintenance. Levee systems are objectionable because a large amount of land must of necessity be on the unprotected side of the structure. As a general rule, levees should be built with a safety factor of from two to eight feet above the estimated high water, depending upon the size of the stream and the watershed. The top width and side slopes depend upon the nature of the soil, since a loose soil would need a wider top and greater slopes than a firm clay soil. The drainage of the protected lands in a levee system is accomplished by the use of ordinary ditches and flood gates through the levee. The design of flood gates is a special problem and cannot be treated in the scope of this paper.

The third form of improvement would be a combined system of levees and cutoffs in the old channel. If a few bends in the old channel can be cut across and the stream shortened materially, it will be advisable to recommend such improvement. In order to determine such necessity, the engineers must be able to calculate the increased carrying capacity of the old channel and the accompanying effect on the height of the levees. To be effective, a system of cutoffs should be carried out. It should be clear that a few cutoffs would affect the old channel only locally, and that at other points there would be a congestion of the flood water. There is not a great deal of information on the benefits of cut-offs in connection with levees. It is a subject that deserves careful consideration and a capable engineer to handle it.

The fourth general plan of reclamation may be called a combined system of cutoffs and improving the old channel. In this form of improvement the effort is to attempt to restore the channel to its former capacity, and to establish it so that it will continue to work at its maximum capacity. In this plan a systematic form of cutoffs must be adopted to secure uniformity of flow throughout the stream. The channel improvement will consist of removing all unnatural obstructions to the flow such as bars, trees, stumps, logs and brush, and the removal and rebuilding of improperly located bridges.

The fifth general form of improvement would be a combination of cutoffs, clearing the old channel, and enlarging it by dredging. This last plan deserves a peculiar consideration because of the fact that the old channel occupies a certain definite amount of ground that will probably always be waste space. If the land to be protected is in a district where the values are high, say from one hundred to two hundred dollars per acre, one can see the necessity of utilizing the present waste space for the improvement.

METHODS OF COMPUTATION

It is not a difficult matter to compute with a reasonable degree of accuracy the carrying capacity of new channels. Chezy's formula, which is, $V = C\sqrt{Rs}$, is universally employed. V is the velocity in feet per second in the channel; C is a factor depending upon the slope, the hydraulic radius, and roughness which is represented in Kutter's formula by N; R is the hydraulic radius and is equivalent to the term, $A \div P$, in which A is the area of the wetted cross-section and P is the wetted perimeter; s is the slope, or fall in the channel, in feet per mile; N, the coefficient of roughness, in Kutter's formula, for new ditches may be taken at .025. For the original channel of streams containing many bends and which may have considerable debris a value of N of .030 to .040 may be assumed for computing its carrying capacity.

The velocity in any channel is a function of the shape, size, slope, and roughness of the channel. It is presumed that the slope is fixed in any ditch surveyed, so that the velocity may be varied by varying the cross-section. The form of section required will depend upon the depth to which it is safe to go, and the limiting of the velocity to avoid severe erosion of the soil. In this connection construction difficulties and methods will exercise some influence. In general a deep, narrow channel will have a greater capacity than the same area of section in a broad shallow one.

The design of flood ways between levees presents some special problems. The usual method is to divide the problem in two parts—the capacity of the old channel when the water is overflowing its banks, and the capacity of the area between the levees. A depth of water is assumed between the levees and two slopes are introduced as well as different factors, or values for N. It is a difficult problem to adjust the distance between levees and their height. No general rules can be given that will apply. With a given amount of flood water to be cared for, the engineer must adjust the distances between levees and their height to meet the local requirements, and to secure a maximum amount of protected land at a minimum cost.

The Purdue Engineering Review

No. 9 PURDUE UNIVERSITY May, 1913

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The *Purdue Engineering Review,* published annually by the Review Board as representative of the engineering societies of Purdue University, consists almost entirely of articles by Purdue alumni.

The *Engineering Review* is intended to act as a review of the practical problems and undertakings met with during the year by Purdue men, and as such serves the two-fold purpose of giving the engineering students at the university an insight into how problems are met and solved in the outside world, and also of keeping the alumni in touch with what other Purdue men are doing along various lines.

The *Review,* depending as it does on the cooperation and liberal support of the alumni for its contents, must also look to them in a large measure for the circulation lists, and it is to the past generosity both in time and money that the present high standard of the book is due. With this in mind the staff wishes to express its appreciation of the support of both contributors and subscribers, which in all cases was most cheerfully given, and to express the hope that they will continue to help keep up the standing of the publication.

FOSTER LYNDE MOORE MINTURN KING WEAVER RAMSAY HOFER KEENAN

The Engineering Review Board

Departmental Notes

SCHOOL OF ELECTRICAL ENGINEERING.

CALIBRATING LABORATORY

In the School of Electrical Engineering during the past year special attention has been devoted to the equipment of a complete calibrating laboratory, and a large assortment of precision wattmeters, voltmeters and ammeters with accompanying precision transformers and shunts of Siemens & Halske manufacture have been purchased and installed. These instruments together with a low voltage heavy current storage battery, provide for the accurate calibration of practically all the ranges of instruments required for either the laboratory or commercial testing. The primary standards are not available for general laboratory use but secondary standards checked against the primary meters from time to time are provided for calibration by the students.

HIGH POTENTIAL RESEARCH

The results of investigations of the phenomena occurring at very high voltages were presented by Prof. Harding at the annual convention of the A. I. E. E. in June, 1912, and the results checked particularly well with those obtained by the General Electric Company at Schenectady under the different climatic and weather conditions. As a different method was used from that adopted at Schenectady, the reresults due to corona seem now to be pretty well confirmed.

The study of corona losses at high potentials as well as a new method of determining very high voltages without the use of the spark gap are now being studied and results thus far obtained will be available for publication during the coming year.

LABORATORY TRACK CONNECTION

The street railway track on the campus is now being connected to the track in the electrical laboratory by means of a special siding on the south side of the power house, thus permitting the test car to run out on the street railway lines without interference from the coal cars on the power house siding. With this change a large amount of new work with the car is anticipated.

WIRELESS TELEGRAPH STATION

The wireless telegraph station is rapidly assuming commercial proportions as communication in both directions has been established with Chicago and messages have been received from Key West, Washington and from the test boat which was sent across the Atlantic to determine the range of the Washington station. It is expected that the power of the sending equipment will be still further increased during the coming year.

PERSONNEL

The instructional corps in electrical engineering has been greatly strengthened during the past year by the addition of Mr. Alfred Still, a prominent English engineer, who has been chief engineer and manager of two large electric companies in England for a period of twenty years and since coming to this country has been electrical engineer of the Lake Superior Corporation of Sault Ste. Marie, Can. Mr. Still has specialized in machine design and high tension transmission work and is at present taking charge of the design work at the University formerly carried by Prof. Moore. Prof. Moore is devoting a large part of his time as chief engineer of the LaFayette Electrical & Mfg. Co.

Mr. D. D. Ewing, head professor of electrical and mechanical engineering at Ohio Northern University, has joined the electrical engineering staff in the combined capacity of instructor and graduate student and is carrying on a large amount of research work in addition to his departmental duties. During the second semester he has taken entire responsibility for the elective work in electric railway engineering in this department.

SCHOOL OF CIVIL ENGINEERING

CHANGES IN COURSE

An important departure from the former course in Civil Engineering is the Surveying Camp. This is to be operated between Commencement and the first of July, following the sophomore year. This puts the school of Civil Engineering in line with Michigan, Wisconsin, Cornell and the majority of universities, in providing more thorough training in field operations. It will enable the regular course of instruction to be improved by more extensive training in professional subjects.

The location of the camp will be at some point in the State of Indiana, yet to be selected—the State Forest Reserve and Fort Benjamin Harrison being under consideration. This will be a camp in reality as well as in name. The sophomore class, accompanied by instructors, will be provided with tents and camp equipage.

The work of the camp will reproduce the conditions of actual engineering practice, including work in the field and office, lectures and recitations on the theory of the work. First of all, a triangular system covering the area of the camp and the base line will be laid out. The angles of this triangulation system and the length of the base line will be measured by precise methods, accompanied by the necessary astronomical observations. Then an accurate topographical and hydrographical survey will be made of the site, showing the contour of the ground; the location of a railway will also be staked out.

This engineering camp has been under consideration for several years but has only recently been adopted by the faculty. It is to be operated toward the improvement of the course in Civil Engineering. The space vacated in the Junior year is to be taken by Hydraulics and additional language study. The course in the Senior year will be improved by more thorough course in reinforced concrete, electrical laboratory work and hydraulic motors.

SHORT COURSE FOR SURVEYORS, ENGINEERS AND OTHER COUNTY OFFICIALS

This year for the first time the school of Civil Engineering operated a short course of illustrated lectures, laboratory observations and conferences upon the different branches of civil engineering. The course was divided into two parts, the first part lasting from January 6th to January 18th, and the second part from January 13th to January 18th. The first part was intended for city engineers, county surveyors and engineering contractors. The course was technical and instruction was given by illustrated lectures, conferences, direct laboratory observation and drafting room practice. The aim of the course was toward the most approved practice in the several lines of engineering, and it was of benefit to all. The second part was intended for public officials, including county commissioners, road supervisors, public health officials and any others interested in this line of work. The difference between the two parts was that Part II was less technical and more general than the instruction in Part I. The aim of the second course of instruction was to familiarize those attending with results rather than with the technical methods of obtaining the results. Under the two divisions which were given there were conferences upon drainage and water power, concrete construction, cement and concrete, materials of construction, highway engineering and bridges, public accounting, contracts and specifications, sanitation of school houses and sewerage and water supply.

LABORATORY FOR TESTING MATERIALS

An investigation of more than ordinary interest has been conducted in the Laboratory for Testing Materials under the auspices of the American Society for Testing Materials. The investigation was of the so-called rerolled rail steel, i. e., of the rods, mainly reinforcing rods for concrete, rolled from old rails. The product of five mills was sampled at various intervals, and some 2,000 bars were collected and submitted to various physical tests. The purpose of this investigation was to determine the proper specifications for the sale and use of this material.

With the co-operation of Professor Endsley, a large number of delicate measurements were made of the deformations in cast side frames and brake beams. In this work the strain gage designed by H. C. Berry, Purdue '02, was used. Tests of this kind enable the design of the castings to be examined and the exact location of surplus and deficiency of material to be located.

HYDRAULIC LABORATORY

The noteworthy additions to the Hydraulic laboratory equipment during the past year consist of a glass enclosed 12-inch Doble Waterwheel, and a 2-inch triplex Gould Pump. A contemplated addition for the ensuing year is a concrete channel to be fitted with weirs and in which a turbine is to be installed.

Thesis work is being conducted on the flow of water and sand through pipes, an investigation of liquids lighter than water for use in differential gages and a study of the flow of water through steel riveted pipes.

STRUCTURAL ENGINEERING

In Structural Engineering the equipment has been increased by the addition of models of a stiff-leg derrick; a joint of a Pratt truss bridge, and the mounting of the large model of a suspension bridge, all of which are being used in the computation of stresses and in design work. Investigations have been carried on for the past year to determine the wind loads on mill buildings and on train sheds and auditoriums. The results on mill buildings were announced before the Western Society of Engineers, October 9, 1912, and can be found in the proceedings of that society. The results are widely divergent from the commonly accepted methods of loading. The work on train sheds is now going on.

SCHOOL OF MECHANICAL ENGINEERING.

There are four general courses of study given in the School of Mechanical Engineering which are designated as follows. Steam, Gas, Railroad and Heating and Ventilating Engineering.

STEAM ENGINEERING

The course in steam engineering includes the design of steam engines and boilers, steam turbines, pumping machinery, cranes, elevators, machine tools and the study of the manufacture and operation of each. The steam laboratory presents an excellent means of acquainting the students with the operation of the machinery and apparatus used for experimental work. It is divided into the main and west laboratories. The floor area in these two laboratories may be conceived when it is known that the two have nearly twice the area of a baseball diamond. The main laboratory contains thirteen steam driven machines among which is a Baldwin compound locomotive engine, a Harris-Corliss triple expansion engine, a Rand compound two stage air compressor and an Allis-Chalmers engine driving a centrifugal pump. DeLaval steam turbines, direct acting steam pumps and engines of various types, vertical and horizontal, complete the equipment. The west steam laboratory contains more apparatus of a similar nature. All are arranged and available for testing and should all be working at the same time the power developed by the engines, turbines and pumps in these two laboratories would be equivalent to twelve hundred horse-power.

GAS ENGINEERING

The course in gas engineering brings out the design and operation of the gas, gasoline, and oil engines, gas producers, automobiles and power motor trucks. The gas laboratory has a cement floor area of thirty-five hundred square feet, with a testing floor in the center upon which engines may be set up temporarily and tested.

The apparatus in this room consists of eleven internal combustion engines, both horizontal and vertical, using oil, gas, gasoline or kerosene as fuel. The sizes of these motors vary from five to fifty horse, with a total rated capacity of all combined of over two hundred horse-power. The fifty horse-power gas producer using anthracite coal, also located in this laboratory, is adapted for special research work. A very important part of the equipment of this laboratory is the calorimeter room. Here the heating values of coal, gas or liquid fuels are determined.

RAILROAD ENGINEERING

The locomotive laboratory is located in a building of brick, which is entirely separated from the mechanical engineering building. A railroad track runs from the laboratory to the New York Central Lines. The laboratory contains a modern locomotive of eight hundred horse-power capacity. The four drivers are mounted upon wheels, so that the locomotive can be run at any desired speed. The drawbar pull is also easily regulated and maintained to produce a load on the locomotive equivalent to the required train load. The steam is made in the boiler of the locomotive by burning either crude oil or coal and both the fuel and water may be measured or weighed. The conditions of operation are maintained as nearly as possible to those to be met in actual practice. When tests are made, sixteen students are necessary to take all the observations besides the fireman and two helpers who operate the locomotive.

HEATING AND VENTILATING

Another branch of the work in mechanical engineering is the heating and ventilating of buildings. This has grown in importance until separate courses have been outlined in class, laboratory, and design room to meet the demands. For the present the special apparatus for this work is located in the west steam laboratory although plans have already been proposed for a new building to be devoted to heating and ventilating and refrigerating engineering.

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A KEROSENE CARBURETOR

C. E. Summers, '06

The rapid development of the motor industry has drawn heavily upon the supply of fuel adapted for use in motors as now constructed. The outlook for future application of portable power points toward even greater development. No other source of power known to engineering science seems likely to supplant the explosion type of motor in this field. In view of these facts, the scientific world, the manufacturers, and the public have been inquiring what fuel can be produced in such great abundance as to meet the increasing demand without reaching a prohibitive price. Much effort has been expended to find a new product which will be a cheap substitute for gasoline in the present type of motor, or to produce a motor or method of carburetting which will make the heavier petroleum products available as fuels. Alcohol, benzol, and other substitutes for gasoline have been tested, but owing to higher cost or limitations in production, give little promise of relieving the situation.

Kerosene presents the most likely solution to the problem. This is true because average crude oil contains approximately twice as much kerosene as gasoline, and while the demand for gasoline has increased many fold during the last decade, the demand for kerosene has normally decreased. Kerosene differs from gasoline principally in the physical properties of greater specific gravity and higher boiling point. Kerosene has approximately 10 per cent. more fuel value per gallon than gasoline, and is obtainable in most parts of the country at less than one-half the cost. Because of these natural advantages, the efforts of most experimenters have been directed toward devising means for making kerosene available as a fuel for internal combustion motors.

Manifolds and carburetors as now constructed are designed for fuel which, when sprayed into the air, immediately vaporizes and is carried directly with the air. This condition is not realized when kerosene is used, since its boiling point is from 300 to 500 degrees Fahrenheit. If sufficient heat is given to the mixture to hold the kerosene in a state of vapor, the entire charge is so expanded, due to the high temperature, that the horse power of the motor is seriously reduced. If we apply but little heat to the mixture, the fuel is only partially vaporized, the remainder creeps as a film on the walls of the manifold, feeds into the cylinders irregularly and divides between them unequally, resulting in little power, smoke, large fuel consumption, and generally poor results. It seems evident, therefore, that no device could be attached in place of the conventional gasoline carburetor which could so treat kerosene as to give perfect results if the charge must subsequently be elevated through a manifold and divided between the cylinders at random. A kerosene carburetor of necessity includes a kerosene manifold.

The device with which this paper deals has been designed with a view to eliminating the causes which have led to failure or meager success in the use of kerosene in the multi-cylinder throttling motor. Fig. 1 shows the device as applied to the average automobile motor. Its essential elements consist of the measuring member A, the regulator B, the distributor C, the vaporizer D, the atomizer E.

It is noted that the measuring cylinder A is rotated by gear connection with the motor. The cylinder is immersed in the fuel so the grooves in its surface fill with the liquid, and such portion of the contents of the groove as is above the lower edge of the port F discharges, due to gravity and suction, into the tube G which communicates with the vaporizer D. The distributor C rotates synchronously with the cam shaft and connects the vaporizer successively with each of the four tubes, 1, 2, 3, and 4, leading to the atomizer cones E placed beneath the intake valve of each of the four cylinders. The sequence of communication between the heater and each of the four distributing tubes is the same as the firing sequence of the cylinders. In this way the flow of vaporized or partially vaporized fuel is simultaneous with the indraught of air through the perforations of the atomizing cones E, insuring the positive introduction and thorough mixture of the fuel with the air in the cylinder.

The regulator B is the vital part of the mechanism. It consists of a sealed metallic diaphragm filled with air and adapted to axial expansion. The diaphragm is so located that it is subjected to the temperature and pressure conditions existing in the intake manifold and consequently in the cylinder during the intake stroke. The air sealed within the diaphragm exerts a pressure upon its yielding walls which, when the external pressure is lowered, causes the diaphragm to expand. An increase of temperature with constant external pressure also causes expansion. Thus the length of the diaphragm becomes an accurate index to the

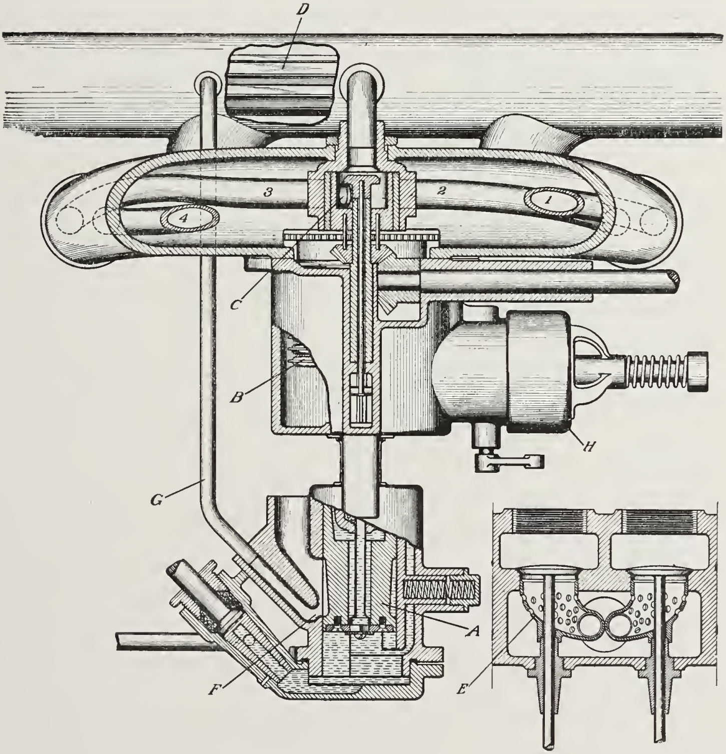


Fig. 1.

volume of any given weight of air, when subjected to temperature and pressure variations. The change in the length of the diaphragm for various pressures and temperatures is determined experimentally, and the volume of liquid fuel necessary to enrich the piston displacement volume of air under these same conditions of pressure and temperature is calculated or determined by experiment. Then by connecting the diaphragm with the feeding cylinder so the collapse of the diaphragm brings a greater length of the fuel slot into discharging relations with the port F, and by giving such form and variation to the depth of the slot that the volume of fuel above the discharging line at each vertical position corresponds exactly to the amount required to enrich the weight of air being taken by the cylinder, a balanced charge is obtained. It will be noted that this method of fuel feeding is independent of the volatility of the fuel. A slightly less volume of kerosene is required than of gasoline, but the greater viscosity of the former makes its discharge slightly less complete, so that this difference is compensated.

In Fig. 2, the curve A-A, co-ordinating external pressures and lengths of the diaphragm, is determined experimentally by varying the pressure surrounding the sealed diaphragm and noting the length. The curve B-B is also determined experimentally, and co-ordinates length of the diaphragm against internal pressure (gauge), and shows the internal-external pressure difference required to overcome the elastic resistance of the walls of the diaphragm for various degrees of expansion. By adding the ordinates of these two curves we obtain the hyperbolic curve C-C, whose equation has the form $X\,Y = C$. Solution of the curve locates the Y axis.

The fuel requirements of the charge at constant temperature vary directly with the absolute pressure, reaching zero at a degree of vacuum at which the clearance gases expand to fill the entire cylinder at the line D-D, Fig. 2. The slope of tangents drawn to the curve A-A indicates the rate of fuel requirement relative to the diaphragm variations. Thus, with the volume of the groove in the cylinder A equal to the volume of fuel required to enrich the piston displacement of air, the variations in the depth of the groove conform to the value of the tangent of the curve A-A for a pressure absolute and a diaphragm length which brings this particular point of the groove on a level with the

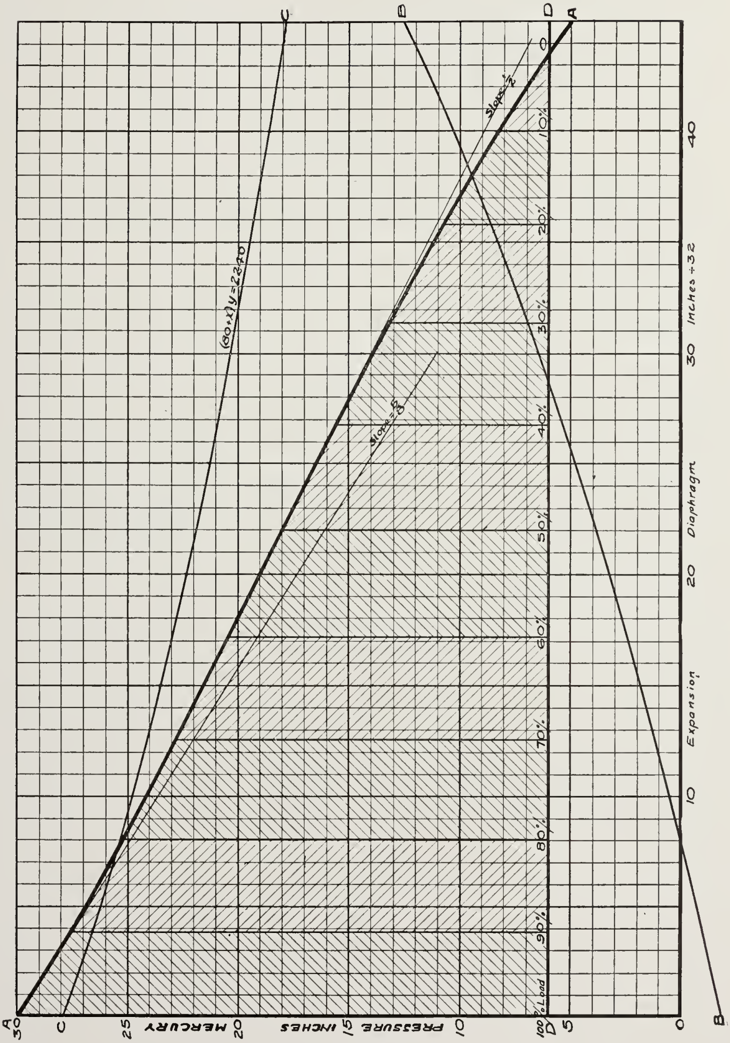

A
B
C
D
(80+x)y=2240
Slope = 1/2
Slope = 5/8
0
10%
20%
30%
40%
50%
60%
70%
80%
90%
100% Load
Pressure Inches Mercury
30
25
20
15
10
5
0
Diaphragm Expansion Inches ÷ 32
10
20
30
40

Fig. 2.

charging line. By this means, not only can a balanced proportion of air and fuel be maintained, but any variations in the proportion found desirable can be given. For instance, at full load of quantity of fuel can be fed giving maximum power, while at lighter loads the minimum amount of fuel is supplied, giving high efficiency and insuring clean spark plugs.

A few of the practical advantages of the carburetor are as follows:

1. A perfectly balanced mixture is obtained at all times, giving maximum efficiency.

2. The device is self-adjusting to all conditions of load, speed, temperature and barometric pressure, thus requiring no manual adjustment.

3. The fuel is introduced positively into each cylinder, and equally distributed between the cylinders.

4. The introduction of the fuel through a separate tube from the main air supply permits of any desired heat treatment without overheating the entire charge.

5. Mechanical control of the fuel supply makes it possible to feed a lean mixture at light loads, thus insuring clean spark plugs, and yet feed a mixture for maximum power at full load.

6. Because the device delivers the fuel directly to each cylinder, vaporized and in its right proportion, and regulates automatically for temperature, it is especially adapted to use low grade fuels.

7. The motor starts easily in cold weather, because the fuel is delivered directly to the cylinder, and a mixture of full richness is fed when the motor is cold.

In practical tests covering several months the device shows even greater economy than would be expected from theoretical considerations. An automobile which averages 12 miles per gallon of gasoline using regular carburetor equipment, makes 22 miles per gallon of kerosene when equipped with this carburetor. The secret of this economy lies in the thorough vaporization of the fuel and the introduction of the smallest amount which will give the desired result. The device has the advantage of using gasoline, kerosene, or any mixture of the two. The impossibility of overfeeding gives it a remarkable fuel economy whether using gasoline or kerosene.

UNUSUAL STRUCTURAL FEATURES OF THE FLETCHER SAVINGS AND TRUST BUILDING INDIANAPOLIS, INDIANA

Louis W. Bruck, '09

The Fletcher Savings and Trust Building is located at the corner of Market and Pennsylvania Streets, in the heart of the business and financial district of Indianapolis, equally distant from the Federal building, City Hall, County Court House, and State House, and within two squares of the four leading banks of the city. The building site on which it stands is valued at 480,000 dollars, the structure itself, exclusive of any interior fixtures, will cost about 875,000 dollars. The building lot measures 97 feet 6 inches by 120 feet, and the building will have a 20 foot basement, with 16 stories above, reaching 217 feet 6 inches above the street level. The Fletcher Savings and Trust Company will occupy the whole of the lower three floors, with exception of the store room space, with their banking room and offices. The remaining 13 floors will be leased for general office use.

The exterior of the building will be finished with white granite up to the fifth floor level, above which Indiana limestone is to be used. A very painstaking effort has been made to impress the observer that the building is a bank as well as an office building. To this end, a great deal of emphasis has been placed on the bank entrance on Market Street. The walls have been set back three feet or more in the three lower stories, and massive granite columns introduced, 35 feet high. These are well proportioned and serve in their arrangement to distinguish the banking rooms from the remainder of the building in a very pleasing way. The attainment of this object has at the same time introduced one of the principal structural difficulties, for the steel columns above must continue down inside these granite columns, thus unsupported in a length of 39 feet. The direct loads on these columns at this point total 762,000 lbs.; and to these must be added a wind moment of 509,000 ft. lbs. The section thus obtained becomes excessive, and other means must be resorted to rather than the addition of cover plates and angles to the existing section. This presents one of the unusual features of the construction, which will be described in detail.

The interior of the banking room itself, elaborate in all of its details, is responsible for other difficulties. Approximately $100,000 is to be expended in the finishing and decoration of this one immense room, which the trust company will occupy. Needless to add, the demands of the architects in designing so large and expensive a room were very exacting. Reference to the plan of the room will show how few are the columns and how symmetrically they have

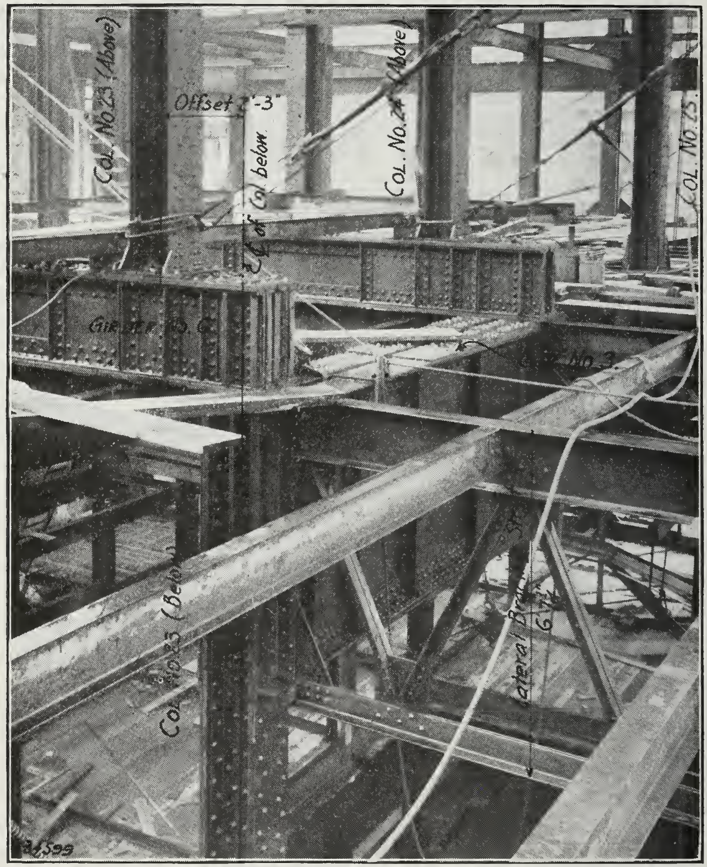


Fig. 1.

been placed to facilitate the working out of certain architectural schemes. In order that the elimination of columns above the banking room may be shown more plainly they have been dotted in on the plan of the room, five eliminated entirely, and 7 shifted in position. Ordinarily the shifting of a column in a skeleton frame building is not difficult, because room is easily obtained, by suspended ceilings or otherwise, and the construction easily taken care of. However the troubles were rather complex in this case. Little room was allowed for the necessary girders, and the construction for that reason was difficult.

Fig. 1, viewpoint of which is given on the plan of the banking room, shows one of the unusual cases of offsetting and elimination of the upper columns. The double six foot girder No. 3, carries columns No. 24 and 25, eliminating them below, while column No. 23, supporting girder No. 3 at the near end carries also the smaller girder, No. 6, the latter made necessary by the offsetting of column No. 23. The second column in the view, No. 24, is offset in a similar manner and its load is likewise transferred to the large girder by means of the smaller one. An unusually small amount of working space was available for the depth of girder No. 6. The vertical shear in the near end of this girder is about 640,000 lbs. and the available depth for the girder was 28 inches. The compactness of the metal is well shown in the view, as well as the close spacing of the rivets in both web and flange. A double I section is used and each of the two girder sections has four web plates, two inside and two outside of the flange angles.

It will be noticed in Fig. 1, that the end connection of the girder No. 3 is riveted. A glance will immediately suggest that it would have been much simpler to rest the girder on top of the column, rather than running the column up through the girder. Some very difficult riveting would have been avoided and the connection made much easier in the drafting room. One consideration, however, makes that scheme an impossibility, and that is the provision for girder No. 6, having a reaction at this end of 640,000 lbs. and coming above the top flange of the larger girder. To transfer this load down through the end of the girder below by means of milled stiffeners was found to be impossible because not enough metal could be assembled in the space available. The only other expedient was resorted to—that of running the lower column up through, and two inches above the top flange of the lower girder to form a bearing connection for the upper girder.

The other troublesome feature of the structural steel work was brought about by the granite columns on Market Street. Fig. 2 gives a detailed view of one of the connections along Market Street at the fourth floor, near and above the banking room entrance. These steel columns are entirely encased by the granite columns, which at the outset prevents any connection to them except from the room side. This gives a free length of about 39 feet for the steel columns which have a direct load of 762,000 lbs. to be combined with a wind moment of 509,000 ft. lbs. The outside dimensions of the columns were limited by the channeling of the granite to 16 inches. To find a section limited to these figures of sufficient strength would have resulted in a section both inefficient, and with excessive thicknesses of metal in both web and flange sides.

Another consideration in the same problem suggested a solution in itself. It was that of providing an efficient connection for the second floor girders at the second floor. These girders along the street, it will be remembered, carry a wall which was set back over three feet from the corresponding wall above. This brought them two feet or more from the columns to which they were to be framed. Because of the architectural features it was not permissible to introduce a girder for framing and even this method would not have given opportunity of transferring wind stresses to the columns at this floor. One means of accomplishing both these objects was to place an auxiliary column, or strut about two feet inside the main column to take these connections with the wind stresses at that level, and to secure the two columns together by means of tie plates along their full length. This method was adopted, and all wind stresses from the fourth floor down were transferred to these auxiliary columns. The main section then carried nothing in the 39 foot length but direct load, and the section for such a load was easily proportioned. The method employed of transferring the wind stresses at the fourth floor is well shown in Fig. 2. The usual wind-bracing-girder, as designed for all the upper floors, is carried along the entire elevation, and connected to the main column by means of a gusset plate connection. A second girder, or latticed bracing is framed between adjacent auxiliary columns, and these connected to the outer girder by horizontal angle bracing. The inner line of girders has no load but that of the transferred wind stresses. Unfortunately it cannot be explained in detail in this article how much this solution simplified the working out of the connections of the floor beams, etc., in the shop details.

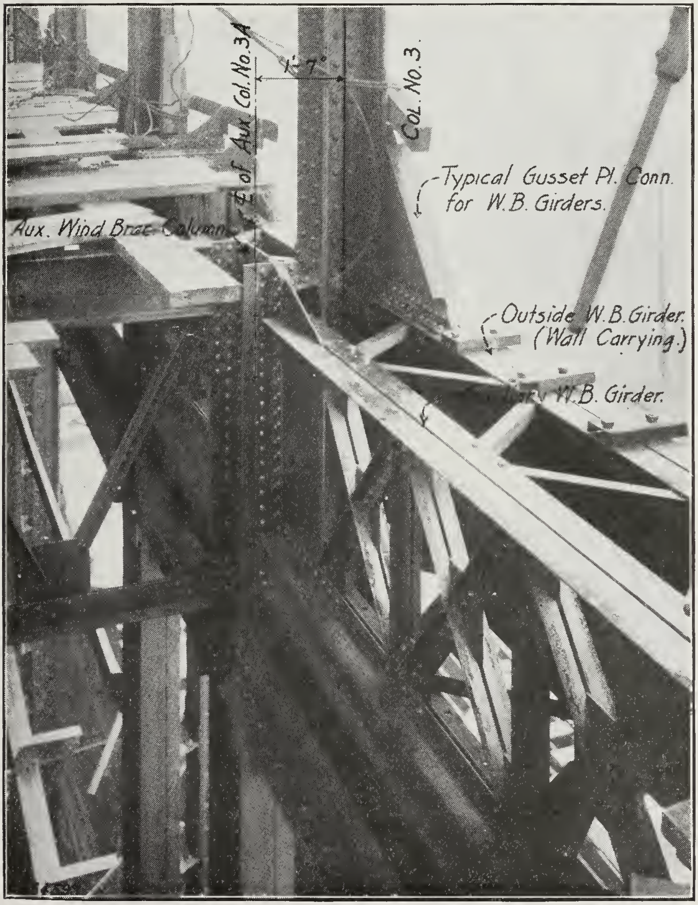

℄ of Aux. Col. No. 3A
1'-7"
Col. No. 3.
Typical Gusset Pl. Conn. for W.B. Girders.
Aux. Wind Brac. Column
Outside W.B. Girder. (Wall Carrying.)
W.B. Girder.

Fig. 2.

Another feature of the design which might prove of interest because its use is not yet common, is that of placing the splice in the outside columns in the middle of the story height—at or near the point of counter flexure. It eliminates the necessity of having very heavy splice plates designed to take the full amount of the wind moment in the column. An advantage of greater importance, however, in the shop is

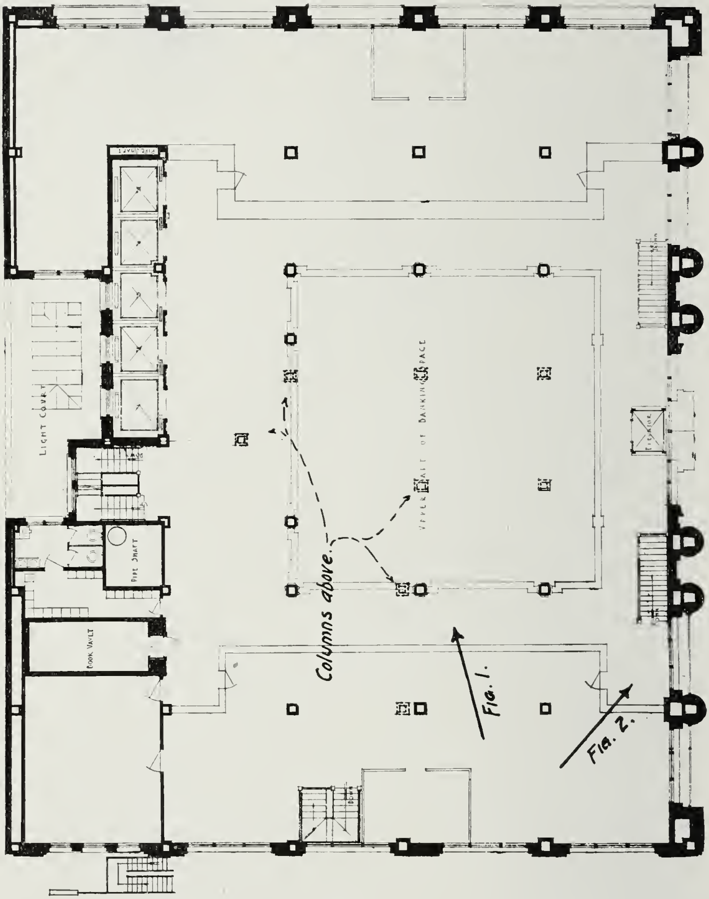


Fig. 3.

Plan of Banking Room.

that the location brings the splices clear of any gusset plate connection from either the floor above or below. In the ordinary design, with the splice 18 inches or two feet above the floor line, the gusset plate connections on the columns interfere with the column splice, and the two must be combined in the field connection—an awkward and costly detail, yet one which usually cannot be avoided.

Such in brief are some of the unusual features of the structural design of the building. They are not stupendous, nor entirely new and original in solution, but they are unusual, and as such they may prove of interest as illustrating some of the problems presented to the structural engineer, for which he must have ready solution. He must prove his value in solving such difficulties quickly, yet with the care and understanding of the methods and materials available that will render his scheme speedy of solution, economical in cost, and efficient in service.

THE LAW OF CONTRACTS

W. E. STARK, '14

All business is conducted through the medium of contracts, and whether it be the ordinary affairs of domestic life controlled by simple agreements or the erection of great public works controlled by carefully prepared contracts, the same law and the same principles apply. Without the medium of contracts business would be at a standstill. No man is able to take his place successfully in business without some knowledge of contract law. The writing of specifications should be considered along with the drawing of contracts. The contract is a proper task for the engineer, in that it must be drawn with reference to the specifications so that they may have the force and effect desired. If the specifications are drawn up by the engineer and the contract by the attorney, conflicts will arise frequently owing to each man's ignorance of what the other has in mind. Between the two evils, lack of legal knowledge and lack of technical knowledge, the former is often regarded as the less important and the contract is left to be drawn by the engineer. A contract prepared without regard for the legal principles is almost certain to lead to litigation either on account of a misunderstanding of the legal liabilities of the parties involved or of the failure to make the contract binding.

To assume the obligations arising from a contract, the law provides that the parties shall observe certain formalities and that their intentions shall be made known by certain acts that may be made a matter of record. There are four essential elements to a binding contract, namely, two parties with the ability to contract; a lawful consideration; a lawful subject matter; and a mutual understanding between the parties. If a contract does not contain all four of these principles, it is not binding and will not be upheld by any court.

The ability of a person to contract is not hard to determine. The only people who have any special privileges in regard to contracts are infants—infants being men under twenty-one, women under eighteen, drunkards, lunatics, and sailors. If a contract is injurious to the interests of an infant it is absolutely invalid, but if it operates for the infant's good it must be fulfilled or its equivalent given when the infant becomes of age. Sailors are especially protected by federal law. If a sailor incurs a debt of more than one dollar while he is on a voyage, it cannot be collected. In some courts, married women and bankrupts are free from obligations of contract.

A contract should always state clearly the residence of the parties as well as the place where the contract is drawn, since the laws effecting its execution may depend on these things to a large extent. For instance, a contract drawn in one state to be performed partly in that state and partly in another will be governed by the law of the state in which it was made, but a contract drawn in one state to be performed wholly within another state will come under the laws of the state in which it is performed. A contract cannot be enforced by any legal act unless some consideration is involved. The law does not permit the contracting of doing something for nothing. The consideration may not necessarily be money. It may be the surrender of a right or a privilege or the promise to do a certain thing. If the consideration of a contract is an act, the performing of that act cannot be taken as the consideration for a second contract. Taking a concrete case, if a workman is on a contract job which he quits for some reason before he has finished it, the promise to complete the job for a premium will not be upheld by the courts. The finishing of the job was the consideration for one contract and cannot be made the consideration for the second. There is a difference between a promise in consideration of some future act and a promise in consideration of a promise to perform some act in the future. If an owner says to a builder, "I will pay you ten thousand dollars to build me a house," and the builder answers, "All right," the promise to pay cannot necessarily be realized upon until the house is built. The owner may call the deal off before the house is completed and the builder may not be able to collect a cent. On the other hand, if the owner says, "I agree to pay to you ten thousand dollars if you agree to build me a house," the contract is perfectly valid since it is supported by a present consideration and not a future one.

Now comes the question of lawful subject matter. Contract law requires that the obligations assumed shall be lawful acts or undertakings within the written law of the land; that they shall be in harmony with the policy of the government and with good society; and that their execution shall be possible. The consideration must not be one prohibited by law. A contract must not tend to influence legislative bodies or public officers in the discharge of their duties and it must not have for its object the perversion of the courts or the obstruction of justice. Agreements to pay money to witnesses to remain out of court will not be enforced. Contracts made for the making of public utilities before the franchise is obtained, or contracts between builders to refrain from bidding against each other are illegal. A man cannot by contract forfeit certain rights and privileges which the law guarantees him. Contracts by which persons agree not to demand damages for injuries or negligence, such as the contracts of railroads, express, and telegraph companies, which seek to limit their responsibility in case of accidents, have frequently been set aside by the courts. The fact that a man riding on a free pass signs an agreement to release the carrier in case of injury to the passenger does not mean necessarily that he cannot collect damages in the event that he is injured in case of accident while a passenger. A case in point is that of the Indianapolis Traction and Terminal Company versus Isgrig, administratrix, in the Appellate Court. The court affirmed a former decision granted in favor of the defendant, stating, in its opinion, that a common carrier created as such by law, cannot contract against liability for negligence. This case arose on account of the death of a conductor in the employ of the company while riding on his transportation slip.

The last essential element of a binding contract is the mutual understanding between the parties as to the terms of the agreement. If it can be proved that a mutual understanding is lacking the mere signing of an agreement will not make it operative. For instance, an engineer draws up two contracts for the approval of his company. Both of them are signed and sealed and the company elects to deliver one of them, but by mistake delivers the other. If the company can prove that it did not intend to deliver the one that was sent, there is no contract. A contract subject to the conditions of some future agreement is held as not binding since the parties have not yet agreed as to the future conditions. It might seem from the consideration of these statements that any ingenious man could evade a contract, but such is not the case. The misunderstanding must be one that any man of ordinary sense would be liable to fall into, and could convince a jury that there was an actual misunderstanding.

It may seem that some points upon which a contract might depend would be decidedly hard to bring out to the court's satisfaction. To aid in the interpretation of contracts and to prevent fraud and perjury, statutes have been enacted which require that important contracts must be attended by certain ceremonies which may be cited in court as evidence. On account of the loss of certain evidence through the elapse of time other statutes have been passed whereby the period of liability of the parties is limited. Most states require that contracts relating to the transfer of lands and construction work must be made a matter of public record. It is required in some states that all contracts and specifications be recorded. The statute requiring that certain contracts be in writing in order to be enforced by court decisions, especially those involving more than fifty dollars in value, is known as the Statute of Frauds. This law usually contains a section governing sales, wherein it is stated that a contract for the sale of goods is not effective unless part of the goods has been delivered or a partial payment has been made. When the statute specifically states that the contract must be in writing, neither party has any recourse in court if this provision is not observed. The statute limiting the time during which a contract obligation operates is known as the Statute of Limitations. It is the purpose of the principles of this type of statute to compel the contracting parties to enforce their rights or abandon them in a reasonable time. Such provision gives security to business and makes unnecessary the indefinite retaining of receipts and like evidence. By its rulings, the plaintiff is denied the privilege of enforcing his former rights after the elapse of the prescribed number of years. However the action only is affected and not the defense. Thus a defendant may show that a contract was procured by fraud even though the statutory limit has passed.

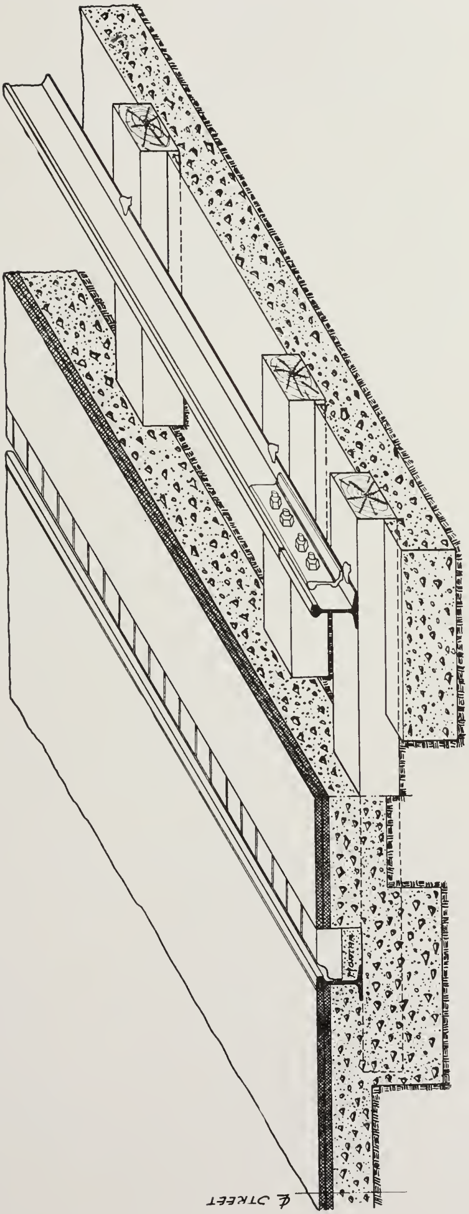
It should be kept in mind that in drawing up a contract very close attention should be paid to the essential elements. When the contract is completed it should be reviewed carefully to see that it does contain these features of a binding agreement, and that it is within the statutes limiting the law of contracts. The preparation of a contract is not a thing to be done hastily and the spending of a few hours of time may mean the saving of many dollars.

TRACK RECONSTRUCTION

J. R. McKay, '11

During the summer of 1905 there were constructed several miles of street railway track of the beam type construction in Fort Wayne. A concrete beam six inches deep runs the entire length of each rail. On the assumption that the beam would be strong enough to carry the track vertically, ties were spaced every five or six feet apart except at joints where two ties were spaced very close to each other. It seems that the tie was counted upon to prevent the spreading of rails and not to distribute the load to any great extent. Reference to Fig. 1 which is an isometric drawing of one track on a street where there is double tracking, will show the most salient features of this type of construction. All the track so constructed in this city has proved a failure. At the present time there is left to be reconstructed only a few miles of both single and double track of this type. Most of this is in such a condition that it will have to be replaced within the next year. It is upon the reconstruction of over 4,000 feet of double track of this type that this article shall be concerned.

Before discussing the reconstruction of the beam type of track it might be interesting to note some of the features concerning its failure. The most glaring fact was that for almost its entire length the track was lower than the adjoining pavement by several inches. In some instances the track was as much as four or five inches below the pavement on either side. Only recently on some of the track which is still in and is to be replaced as soon as spring opens, it was necessary to shim the rail up seven inches in order to permit cars to run over the spot. This fact in itself shows that the beam was very inferior to most ordinary types of construction and that there was not sufficient width in the beam to properly sustain the load and transmit it to the subsurface whose bearing power is poor. At joints, where there was considerable vertical motion, the beams would break, and during wet weather, under the continuous rise and fall of the track as cars passed over these points, the subsoil would work its way to the surface through the beam and pavement. When the concrete beams were removed it was



CONCRETE BEAM CONSTRUCTION

FIGURE 1

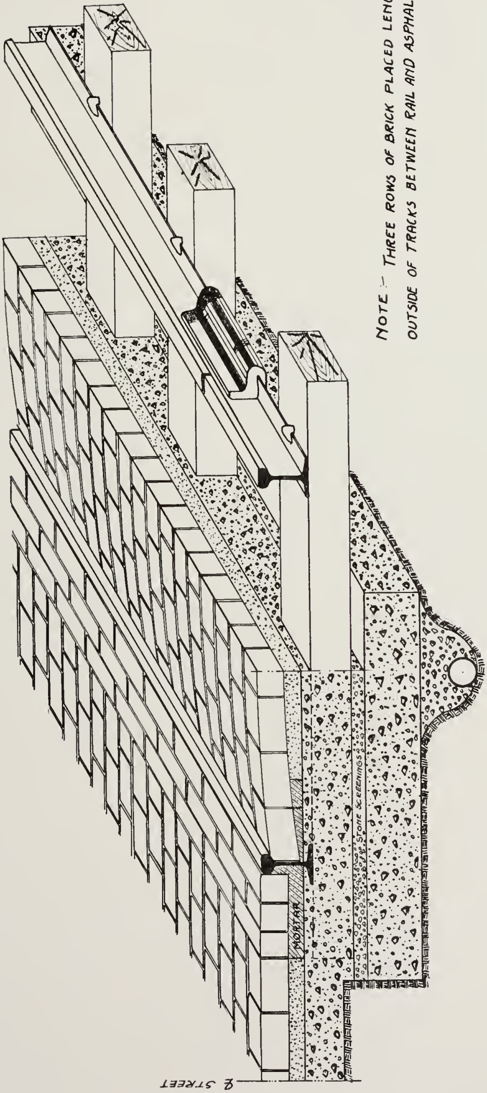
found that in many cases they were broken between the wide spaced ties.

To overcome the various bad features of the beam type and to provide a roadbed which will stand interurban and heavy city traffic, a standard type of construction as shown in Fig. 2 has been adopted.

The stability, permanence, and maintenance of any street pavement depend upon its foundation. If the foundation weakens in any way, the surface will soon settle unequally. If the street be one in which street railway cars are run this settling soon manifests itself in the breaking of the bond between the pavement and track construction. However, surface failure may be due to poor materials and workmanship independently of a good foundation. The essentials necessary for the construction of a solid unyielding foundation are a firm subsoil and proper drainage. The nature of the subsoil will to a large extent determine the character of the construction to be used.

The drainage of the track in a paved street, as that of a steam railroad, is one of the most important items in the economical maintenance. Under the increased loading, the rail tends to deflect and consequently the bond breaks and permits water to enter the foundation, which if not properly drained will at once displace the subsoil and break down the entire construction. The drainage is cared for by subdrainage and surface drainage. The subsoil is drained by a line of four inch vitrified ring tile placed in the center line of the track. The tile is surrounded by crushed stone to permit the water to collect and enter the open joints of the tile without carrying soil with it. The more solid and compact the subsurface is made the better the drainage will be. Hence before the under drainage is placed, the soil is thoroughly rolled with an eight ton roller. This rolling also furnishes a firm foundation for the concrete slab.

The surface drainage is cared for by drips which are connected with the city sewerage system by eight inch vitrified pipe lines. The drips are placed at breaks in grades on downward slopes and where there is a slope of such length as to warrant the reducing of distances. The small four inch drain lines are connected to the outlets of the drips. Thus the water which may get below the track construction and that which collects along the rails in the flange-way spaces is adequately taken care of.



NOTE:- THREE ROWS OF BRICK PLACED LENGTHWISE LIE ON OUTSIDE OF TRACKS BETWEEN RAIL AND ASPHALT PAVEMENT.

CONCRETE SLAB CONSTRUCTION

FIGURE 2

To carry a heavy interurban car without crushing and to prevent joints from loosening, a foundation of concrete of varying thickness and seven feet six inches wide is used. This foundation is of a 1:3:5 mix and in the work of the past summer it was eight inches thick. In order that there may be sufficient elasticity to permit cars to ride easily and not jar, a cushion of two inches of crushed stone is placed on the concrete foundation. In places where it is desired that there be great rigidity, the surface is obtained by blocking up the track and then pouring a wet, rich grout beneath the ties. The blocking is subsequently removed.

White oak ties 6 x 8 in. by 7 ft. spaced two feet on centers are employed in the standard of construction now used. The 7 in. 91 lb. T-rail, 60 feet long, is heavier and stiffer than that formerly used and therefore will retain a permanent alignment and grade. Such a rail also reduces vibrations and deflections to a minimum and prevents the rapid deterioration that would result in the use of a lighter section. Its height permits the placing of a brick under the ball and permits of a better appearing pavement. A 60 foot rail while not so easily handled as the shorter ones reduces the number of joints 50 per cent. and gives a smoother track. All joints are cast welded at an additional cost of more than 250 per cent. above the cost of ordinary splices. A brick surface between tracks and 1 foot outside of the outer rails is used in every class of pavement. The chief reason for this is that when it becomes necessary to open the track for any purpose the brick can be removed easily, and replaced with less cost and damage to the appearance of the street than is the case with other types of pavement.

The track constructed upon plans of the more recent standard construction is located on a street which is the artery of traffic for practically the whole rural district southwest of the city. During the improvement of this street it was necessary to keep at least one side open to traffic, and one track had to be available for city and interurban car operation. Because of these facts it was necessary to carry the work on with the greatest dispatch.

The work of excavating was done with a Thew shovel having a capacity of ⅝ of a yard. With a work car and gondola at hand this shovel operated by a competent engineer was able, in spite of constant interruptions, to remove on the average 200 cubic yards of material per day. Not only did the shovel tear out all the old concrete beams but the ties as well. More work was done at a very much lower cost than would have been possible by hand. The cost of removing this material by hand would have exceeded a dollar a yard as the beams were of such dimensions that they could not have been handled without first breaking them into suitable sizes. The shovel did its work so well that only two men were needed to follow up and do the fine grading. Perhaps the most valuable feature of the shovels work was the time saved.

As soon as the shovel had finished enough of the excavation to insure that the concrete mixer would not catch up, the work of placing the foundation was commenced. The mixer used was of one bag capacity and was run by a motor, which took current directly from the trolley wire. This machine with a gang of 18 men and a foreman was able to lay nearly 500 feet of foundation per day. After the concrete had aged sufficiently (one week or 10 days), the track laying gang started the placing of ties and rails. After placing 500 feet of track it was surfaced. The grade could not be obtained in every case from the adjoining pavement as it was no longer on a uniform slope. It was necessary to take levels over a distance of several hundred feet and then fit a grade to the conditions differing as little as possible from the original grade.

Immediately after the track had been surfaced and lined, the mixer which had already reached the far end of the track was removed to the starting end and the work of concreting the ties in place and putting down the pavement foundation was commenced. This work progressed almost as rapidly as did the work of laying the slab foundation so that it was not long before the paving gang was able to start its work.

Before the paving was begun the joints were cast welded. A gang of 12 men with a foreman were able to cast about 36 joints per day. The welder used consisted of a cupola mounted on wheels with a steam engine attached for creating the necessary power for blast. All joints were ground off smooth by an electric grinder made by the Kerwin Machine Company. This machine is automatic and can grind 20 to 25 joints per day depending upon the hardness of the rails.

After the entire west track had been completed, work was started on the east track and carried out along the same lines. The organization on this work was excellent and because of the efficient management both tracks were completed and opened to traffic within a little over three and one-half months, in spite of the fact that the work was hampered by bad weather. The track and pavement are the equal of any in the city and will without doubt stand up under a good many years of hard wear.

SUMMARY OF ACTUAL COSTS

Excavation (including all materials and labor) per cu. yd.	$0.39
Track Work (materials and labor for removing and relaying) per ft. single track	1.96
Special Work (one left hand turnout, total length 84 ft. with labor for installing) per ft. of track turnout	6.54
Cast Welding and Grinding per Joint	5.08
Drainage per foot of single track	0.16
Concrete per cubic yard	3.68
Paving (materials and labor for laying surface only)	1.09
General Expenses (Engineering, Watchmen, etc., per foot of track	0.10
Overhead (changing trolley, etc.) per foot of single track	0.009
Average cost of entire work per foot of single track	5.15
Average estimated cost per foot of single track	5.62
Net saving per foot of single track	0.47

AN AMERICAN STUDENT'S IMPRESSION OF A GERMAN ENGINEERING SCHOOL

G. A. Wainwright, '11

"Purdue University? There is no such a thing. I am quite familiar with the geography of America and there is no state named Purdue." This was my own rather discouraging reception at a German technical school and it almost led me to believe that registrar's clerks are of a cold and suspicious nature the world over.

I found it quite impossible to pass the outer guard with my Purdue credentials, but on presentation of my high school diploma—a very pretentious and elaborate document—I was immediately treated with the deference which should be due the proprietor of such a paper. My Purdue diploma might be all right—he still had his doubts that I was working a confidence game—but unless I could prove that I had attended a high school, I was not of the elect. His misunderstanding of course arose because of the fact that their *Hochschule* is in reality the *high* school of the country, and since the entrance requirements for foreigners require the attendance at some high school he was not aware that in our use of the term it is a misnomer. This is merely an example of the red tape which all German public institutions permit to hamper them. The American student's first impression is that there is an inexcusable lack of system to the whole organization. This idea gradually gives way to a doubt as to whether or not there is really too much system; so much that the place is involved and entangled in it until the whole effect is that of hopelessly intertwined red tape. When one considers the appalling fact that the process of matriculation, which we require about twenty minutes to complete, there consumes five days, it is easy to believe that at least something of office efficiency has been sacrificed to departmental formulae.

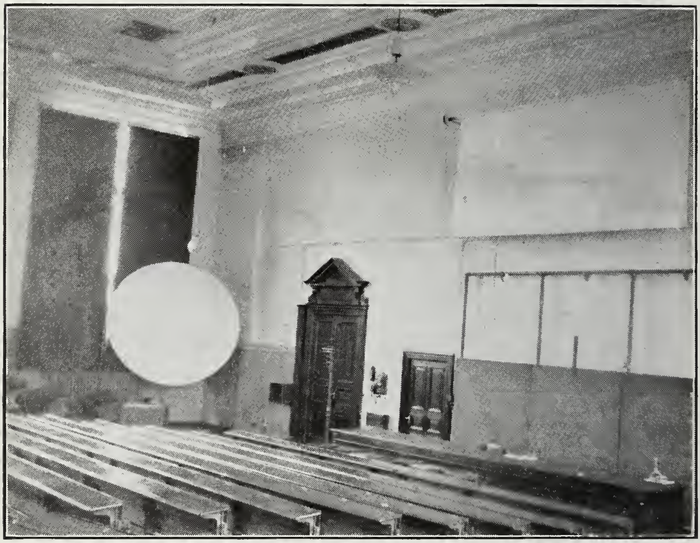
My references here will be largely to the *Königliche Technische Hochschule zu Berlin* as I am more familiar with the details of it than with any other. First your credentials must be filed and receipted for in the office of the secretary. At the same time he takes from you a deposition concerning your personal and family history that is nothing if not complete. No little detail can escape this inquisitive question blank which covers everything from the social rank of your grandparents to the number of murderers in your immediate family. There intervenes then about two weeks while a no less personage than the *Minister der Geistlichen Angelegenheiten* considers your credentials. The first real important step in matriculation then occurs when you have your prescribed personal meeting with the rector. He is an awe-inspiring potentate who may be addressed only as *Euer Magnifizence,* and on the occasion of this first meeting he grasps each new student by one hand and thrusts into the other a bundle of entrance papers and a small library of rules and regulations; after which he gives a short address of welcome strangely reminiscent of what many American college presidents say on similar occasions. The student then lists the subjects he chooses to take on a paper furnished for the purpose and turns it in to the registrar for him to calculate the fees. Each course is paid for individually and the instructor usually shares in the money which is paid by his classes. A very wise provision is made in the collection of a trifle for the academic sick fund which insures the student free medical attention and very cheap medicines and nursing.

After only a short delay—two or three days—the paper containing the student's planned work is returned to him, and a day or so later an opportunity given to pay the fees. The paper need be signed by the head of the general science department and each professor under whom work has been elected and the student is ready to start. The choice of subjects is left absolutely to one's own sweet will. The catalogue even apologizes for grouping them under department headings, saying that in so doing it is not attempting to influence or restrict the student's choice of subjects, but begs to recommend what is a very good course. To one who has ever attended a school where the catalogue, with full knowledge and consent of the faculty, plainly intimates that you "may take the following named subjects in the following named order, or you may seek your education elsewhere," this becomes a real lark. To be sure, in order to qualify for an examination a certain list of things must have been taken, but if the student prefers to take the senior year first or chooses to spread the four years' work out over eight, no great obstacle will be placed in his way.

Attendance is also purely elective. If you attend classes, no one will know it, nor will they if you do not. There are no roll calls. In the beginning the rector advises the student to attend classes "as often as convenient," but there is no attendance committee to encourage the adoption of this advice. Men occasionally attend only the two times a semester which are necessary for the signing of their *Anmeldebogen* and trust to home study and diligent cramming to pass the examinations. In technical schools there are two of these examinations: a preliminary after two years and a final at the end of four, which when passed leads to the degree of *Diplom-Ingenieur*. These are most thorough and grilling affairs and it is safe to say that without real knowledge of the subjects they are impossible. They are both written and oral and the final thesis or *Arbeit* must be an enormous affair and represent practically a year's hard work. The oral quiz, though held in the morning, must be attended in full evening clothes by both students and professors. They regard this the most important moment in a man's life and they do not propose to have the dignity of the occasion marred by anything as frivolous as a red necktie.

The most lavish thing about a German school is the vacations. The school even starts with one! For three weeks after the announced opening of school, not a class is held. The German people present a strange paradox in their observance of rules. It is well known how implicitly they obey their signs of *"verboten"* and how countless absurd regulations are adhered to to the letter, simply because they are regulations, and yet in other cases hard and fast laws are consistently ignored for years without any apparent reason. Their Christmas vacation, nominally of two weeks becomes three in practice and a like period at Easter stretches into a month. Frequently other single days and week ends are interspersed throughout the year and make quite a large total: Thanksgiving, Ascension Day, Whitsuntide, the Kaiser's birthday, etc. At the end of the school year the students commence going home two weeks to a month before the real closing date and the professor himself calmly closes up shop and quits when the last one has left.

The actual work done is almost exclusively by lecture and in laboratories. A view is shown of a large lecture room in *Königliche Technische Hochschule zu Berlin*. The large circle to the left is a picture screen. The projection apparatus is directly in front of it and hence may be operated by the lecturer without an assistant. The black-board is in three sections, each of which may be raised independently by hydraulic pressure to permit those in the rear to see the entire board. In some cases the colloquium and seminar correspond in a fashion to our recitations, but these occur in only a few subjects. It is in the personnel of the lecturers that the great and incalculable superiority of the German technical school over the American is manifested. These men are the acknowledged superiors in every line of work in the Empire. When a man has done so much and accomplished so many things that the nation is at a loss how further to reward him, he is presented with the title of "Professor" and he becomes a man apart, for this is an honor respected and revered as no other in civil life. I have in mind a man who rose from the ranks as a shop foreman, through factory superintendencies and managerships until his fame was nation-wide and he was regarded in the mechanical world as a marvel of skill and inventiveness, and when through his wonderful organizing ability he had attained to a place in industry second almost to none, he



A Lecture Room.

received a royal command from the Kaiser to go to Charlottenburg and teach school. It speaks much for the efficacy and good standing of a school system when a man like the betitled *Herr Geheimer Oberregierungsrat Professor Doctor-Ingenieur honoris causa* A. Martens, a man whose connection with the steel industry will never be forgotten, still cares to ally himself with the instructional staff of a technical academy.

Germany takes her schools seriously. The student is in an exalted class in their society, and in a land where caste is a so vital consideration, his enviable position lends a tone to the whole educational scheme that is an enormous factor in making the schools what they are. He is the idol of the people in his gay-colored cap and his ribbons, and his huge scars excite admiration wherever he goes. He may visit the royal theaters at a fraction of the admission price and the royal museums free of charge. He even carries a card which makes him exempt from arrest, but he in turn in the full consciousness of *noblesse oblige* does not abuse this concession. (Let us shudder to think what would happen to some of the landmarks of Lafayette a few hours after some such cards were issued at Purdue.)

I have heard so many times the query, "Is it any value to an engineering student to study in Germany? Are there not more and better schools in America?" Let me say most emphatically that there is value, and great value in it. We have long conceded that we are a nation of engineers and that most of the work of importance that has been done in mechanical and civil lines has been done here. Blinded by our own glory, we have scorned the Germans as a nation of school teachers and scientists, and have failed to note that in their slow and painstaking path through the complicated ways of theory, they have come upon countless practical discoveries, and just as surely as they are becoming the admitted leaders of the world in commerce, so surely will they be able to give the United States a furious struggle to maintain her world supremacy in manufacture. They have practiced scientific management under other names for years and with that sharp faculty for assimilation which characterizes them they have absorbed all that is being done elsewhere and the result is one may look in vain for more modern and efficient shops than are found in Germany. The value of their schools lies primarily in the caliber of the men associated with them and the limitless opportunity for individual research in well equipped laboratories with the counsel of these same highly competent men always at hand. The secondary value and one by no means to be overlooked is the opportunities they offer of permitting a man to get an entirely different angle on affairs in general and to learn how other people think things out.

Their instructional methods are painstaking and accurate. The lectures read to the student are largely the result of the personal investigation of the lecturer. He takes nothing for granted and quotes other authorities whose work he has not personally verified only under protest. The work is inclined to be very theoretical and for this reason it would be of little value for one not a graduate of engineering to study there. One must know the fundamentals and be able to select for himself the valuable from the "of scientific interest only" or the work would be a maze of hopelessly useless matter which is in no wise simplified by the strange surroundings and stranger tongue. To illustrate, I recall a very distinguished lecturer's exposition of the so-called diamond point lathe tool. He set the point of the tool at the origin of 3-axial coordinates; developed each surface on the various planes of reference by descriptive geometry; and finally evolved equations for all the surfaces and lines bounding the tool. While this makes a very interesting two hour discourse, it might be a little vague to an American sophomore how it applied to machine shop practice. They give almost no shop work but in lectures detail every possible operation so fully that a man of any practical experience at all can follow them closely. Students who take examinations are required to produce evidence of a year's work in some shop along the line of their course.

The laboratory facilities are bestowed with a lavish hand in most of the schools. The *Königliche Technische Hochschule* in Charlottenburg has an engineering laboratory that cost more than two million dollars. The opportunity for individual research is such that the American student will find he can not duplicate in his own country. Limitless time is at his disposal and if his work is meritorious, almost any equipment he suggests will be obtained for him.

The undergraduate laboratories are very unlike ours. The rules, for instance, say that "the student is earnestly requested to hand in his report on experiments performed, for his own good." I do not recall that this form of obtaining reports is used at Purdue University. The reports themselves are purchasable in printed form and only the actual data and calculated results are necessary to complete them. In the laboratory, there are servants who start the engines, fire the boilers, open hot indicator cocks and clean the machinery after tests. The student is rather above menial labor. It is also quite right and proper for some one to relieve any suffering fellow student while he goes over to the bar in the main building for some beer or coffee. It is interesting to note that the engineering laboratory is treated purely as an aid to design rather than as a training school for operation of power equipment. For example, when we examine an engine for most efficient cut-off, they would probably experiment on various shapes of D-valves.

Inspection trips are frequent and very well conducted. They are made up only from the hearers of the particular lectures which they are to supplement and are hence very small parties. The factories inspected feel so signally honored by the visit of the students that they spare no pains to show their appreciation. Excellent meals and unlimited beer are always served to the students at these plants and addresses of welcome and many little attentions are fairly showered on them. These opportunities to see up-to-the-minute manufacturing and systems for promoting factory efficiency which would most certainly not be available to an American in any other capacity than as a student are in themselves well worth the trip over there.

The German students are companionable fellows and really little different from us if we disregard the superficialities. In general they are four or five years older than men in the corresponding school years in the United States, but this applies in all professions. With the German proneness to enjoy life a little as he goes along and not rush into it and have it all over at once, very few professional men complete their education and become self-supporting before they are thirty. This added age and the natural temperament causes them to assume a dignity quite foreign to the American student. There is no noisy relaxation between classes and jokes like campus tickets and ohm-sifter requisitions are quite unknown. They take their places quietly at lectures and sit respectfully throughout them, scuffing their feet perhaps if the professor does not speak loudly enough, but never throwing chalk or playing catch with erasers when his back is turned. They read daily and religiously the notices that are posted on the black bulletin board and never is there a pencil scrawl on the margin of an official notice "letters poor," "do over," although they do occasionally make a respectful annotation when the notices carelessly refer to the student body as *die Studenten* instead of *die Herren Studenten.*

School athletics are unknown—possibly due to some difficulty they might have making something rhyme with *Königliche Technische Hochschule* in a yell—and beer drinking and fencing are about the only indoor sports that appeal to them. These are not as exaggerated as is often represented, for it is drilled into the *Fuchs* by his older "brothers" from his first day in school that he must never become intoxicated under any circumstances.

Many of their customs are amusing and interesting in the extreme. Their whole attitude toward the work is different from ours. If a lecturer is late, they do not cut the class promptly at five minutes after the hour, but sit around and wait very impatiently for him to arrive. If he is quite late he is reprimanded on his appearance by a loud scuffing of the feet on the floor. Approbation is expressed by stamping and one soon acquires wonderful aptness in this footwork and it is never long until the most verdant freshman is able to scuff promptly when an assistant drops an eraser or stamp furiously when the lecturer tells some particularly good professorial joke. (Professorial jokes are perennials in Germany as in many other countries and spring up annually in the same place) The seats fill up from the front, not from the rear, and many go to class half an hour early in order to secure good places. The professor enters after all are seated—never before—and greets the students with a formal bow, which they often return by rising in their places. Important school functions, such as installing a new rector, are attended by representatives of the numerous clubs and organizations in the most resplendent of uniforms and paraphernalia. The costumes present a beautiful mass of gorgeous colors and the soldierly bearing of the men make these gatherings a truly imposing sight.

"Is the German which one learns in two years in college sufficient to meet the needs of an American student?" It is not. But added to this, two months of diligent effort in the midst of German speaking people will enable the student to understand practically everything. The cost of a year in

Germany of course depends upon the man. The living is about as expensive as it is here, especially in the larger cities. The tales one so often hears about the ridiculously low cost of living are myths or else have their foundation in the past. A thousand dollars should cover the expense of one year bountifully; fifteen hundred, two years—for experience is a great economizer.

The man who can avail himself of a year's study in Germany and does not is committing a grave crime against himself. I need not touch on the cultural advantages of contact with this the most artistic and philosophical minded people in the world, nor the unexcelled opportunity to hear better music, see better art and attend better drama than is offered in any other land, but purely from the standpoint of the young engineer who is anxious to place his time and capital where it will bring him the greatest return. I am convinced that he will find no better investment than a few semesters in a German technical school.

ELECTRICAL HEATING UNITS AND HEAT INSULATING MATERIALS

M. E. Louth, '13

At the present time, there are four ways of changing electrical energy into heat: first, by the Joulean effect; second, by the electric arc; third, by the electric spark; and fourth, by electrolysis. In small electrical heating devices the Joulean effect is used. Since this effect depends directly upon the electrical resistance of the circuit, the question of electrical heating is diverted immediately to finding an electrical conductor which has a high resistance, and which shall together with this property have a reasonable manufacturing cost and good lasting qualities. Such a conductor has been found in a nickel-chromium alloy which is manufactured under various names, though the fundamental chemical formulae and qualities vary only slightly.

The question of unit construction now has to be considered. Will convection or conduction be better is the question which every heating engineer has to answer when designing a new device. A very common type of convection unit is found in the street car heater of today. A helical coil of wire, wound either on an insulator or suspended in air, is allowed to come in contact with cold air. A convection of heat follows, carrying the heat to the parts of the car desired.

The conduction type of unit is well illustrated in the electric flat iron unit. The fundamental construction consists in winding an insulator, such as mica, with a flat resistance wire, the unit being insulated on each side by mica, and then clamped securely against the metal part, which acts as the heat conductor. The larger part of the heating devices on the market at this time are constructed in this manner.

The entire field of electrical heating elements designed with round resistance wire is covered in hot air heaters, electric grills, horizontal toasters, and immersion water heaters. The unit is wound on a lathe or turning device. A slight pull on the unit spreads the coils and eliminates danger of short circuiting any section. The resistance wire may be carried directly to the terminal plugs, but it is more advisable to end the heating unit on one of the supports and run a low resistance wire, such as copper or nickel, from the end of the unit to the plug. This method eliminates a conduction of the heat to the plug, which will in turn decrease the chance of plug failure. The construction of units of this kind is very simple and leaves only the one problem for the designing engineer in determining what shall be used to support the resistance wire. Obviously, it must possess three qualities. First, it must be a non-conductor of electricity; second, it must be able to withstand a temperature of 700 to 800 degrees Fahrenheit; and third, it must possess enough mechanical strength to eliminate danger of breakage. The problem has been partially solved by the use of asbestos board, which, however, is not completely satisfactory on account of its mechanical properties. This material is best known as "Tegit."

Passing now to the more common flat wire unit, the problem of electrical insulation is still the main one. Trouble arises from the fact that all electrical insulators are unfortunately good heat insulators. If this were not the case, the flat wire could be wrapped upon a thin sheet of insulation with the same material on each side, and then clamped securely to the plate to be heated. Since this ideal electric insulator allows the heat to pass through directly to the plate, the wire and the plate will be at practically the same temperature. That would mean the end of the engineer's trouble. Burn outs and punctures through the insulation would be a thing of the past, for these are due to the extremely high temperatures at which it is necessary to maintain the wire in order to obtain the necessary amount of heat at the point of utilization. Since this ideal has not been reached, we naturally turn to that material which approaches these ideal requirements. The field narrows down to the two general classes—a fire proof combination in which the wire may be imbedded, or mica, on which the wire may be wound.

In using the imbedded system, the material must be at least 0.015 inches thick. This means that a large per cent of the heat is lost in being forced through to the heating plate, and that the efficiency is correspondingly low. In this type of unit, the air does not come in contact with the wire, which construction eliminates any danger of oxidation. This is, however, of secondary importance, since the nickel-chromium alloys oxidize only to a very small extent.

This leads us to the consideration of the mica wound unit. A notched piece, or arbor upon which the wire is wound, is placed between two pieces of mica and clamped to a heating plate. Mica can be used as thin as 0.005 of an inch, and will conduct the heat fully as well as a fire proof clay or varnish. Not only does the mica wound unit possess this added quality, but it is less difficult to construct, and if a burn out should occur, the renewal is but a few minutes' work. Mica, however, is very expensive, especially in large pieces. The growing demand for this type of unit has lead to the manufacture of "Micabond," which is scrap mica, held together by a cement. The factor of safety demands that it be used not less than 0.010 of an inch thick. The cement, or binder, burns out as soon as heat is applied, but since the pieces are clamped between plates, no damage results. The binder used in Micabond has a detrimental effect on resistance wire, since a chromium oxide forms on the outside of the wire, when burned at a high temperature. For this reason, pure mica should be used in all places where the cost over Micabond is not prohibitive. Most types of heating devices may be designed by the methods which have been indicated. Heating pads are an exception to the rule. It may be necessary to have a unit which may be bent or rolled into any shape without short circuiting or harming it in any way. To meet this demand, a resistance wire wound with an asbestos cord is used. The wire is bent back and forth, and is stitched to the sides of the pad to hold it in place. The efficiency of the pad is very low. This, however, is not made a point in the design of the pad, since the wattage is extremely low—the average pad runs about fifty watts.

In small electrical apparatus, such as irons, toasters, hot plates, and air heaters, it is not practical to attempt to prevent loss of heat by using a heat insulating packing. If we should take heating units, such as have been described, and place them in or around an oven, we would have a workable electric stove. The efficiency would be very low, and the cost of cooking, when compared to the cost when coal, wood, or oil is used, would be prohibitive. An electric stove, unless built on a fireless cooker principle, will be a failure commercially. In designing a fireless cooker, two questions have to be settled. First, what material shall be used as the heat insulator, and second, how thick shall the wall of insulation be made.

To solve the first problem, apparatus consisting of two sheet iron boxes with one inch space between the inner and outer box was constructed. The tops of the boxes were covered by a thick sheet of asbestos board to prevent a loss of heat upward. Four thermometers were used, two being placed on opposite walls of the inner box, and two on the outside of the outer box. The average of each pair was used as the true reading. The material to be tested was packed between the two boxes and covered over with the asbestos sheet. The source of

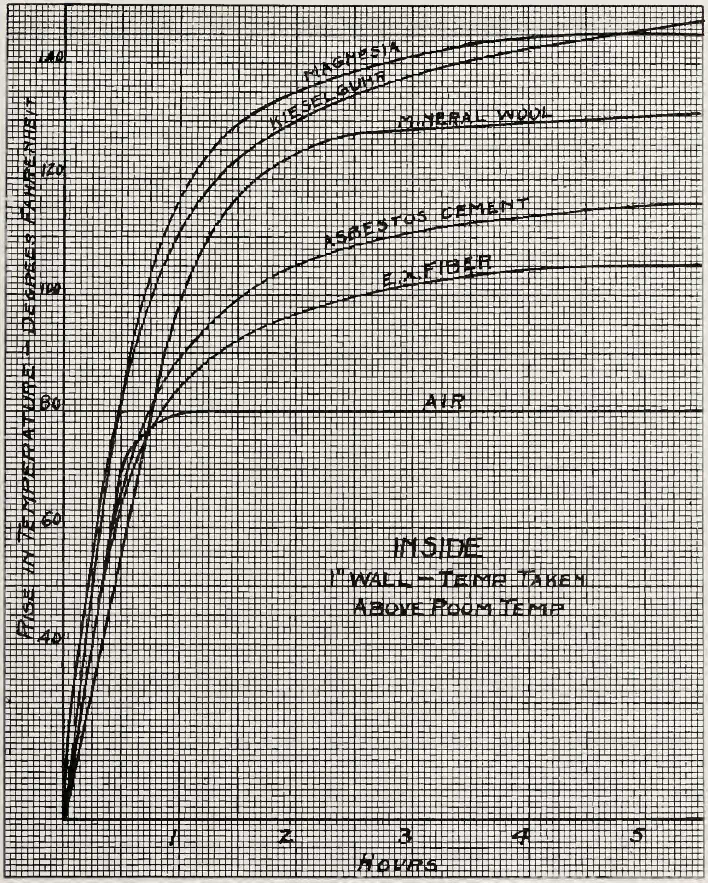


Fig. 1.

heat placed as nearly as possible in the center of the inner box. A sixty watt lamp at a constant voltage was used to give the constant heat required. Every precaution was taken to keep the test room at a constant temperature, and to keep all drafts away from the outside thermometers. All kinds of materials that might in any way be used for installation were tested in this manner. The tests would not, of course, show the efficiency of any one insulator, but would give a comparison of the different efficiencies.

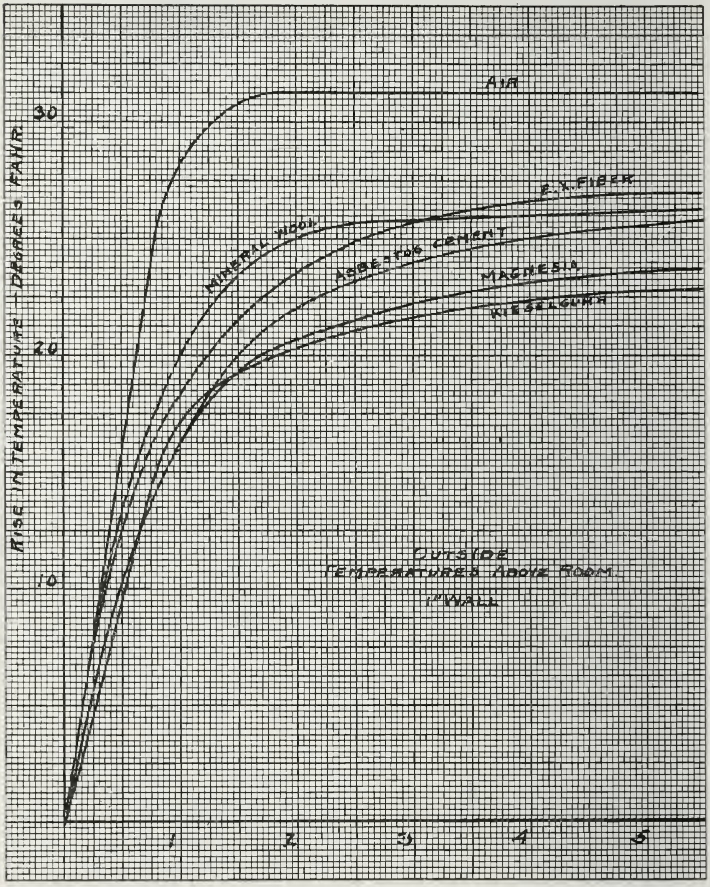


Fig. 2.

Three sets of curves shown in Figs. 1, 2, and 3, were plotted for the best insulators. The curves for air are also included to give a standard for comparison purposes. Fig. 1 shows curves with the temperature of the inside box plotted against the duration of time in hours that the test was run. The temperature plotted in all curves is about that of the room. Fig. 2 is a group of similar curves, with the ordinates showing the increases in temperature of the outside box, which depends directly upon the amount of heat that leaks through the insulation. Fig. 3 is a combination of the curves shown in Figs. 1 and 2, with the ordinates subtracted. The new ordinate represents the amount of heat

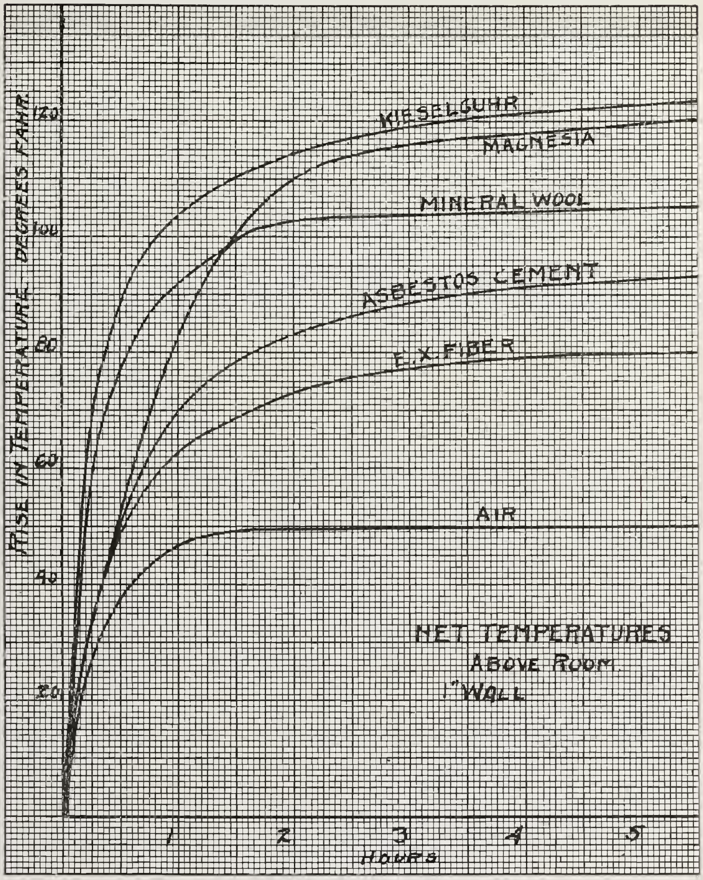


Fig. 3.

which the insulator has retained, and therefore, will give comparative results of the tests of the different insulators.

It is interesting to note in curves how quickly the air insulation reaches its equal radiation point. That is, after an hour and a half the amount of radiation just equalizes the amount of heat generated by the lamp. From that time, the curves continue in straight lines parallel to the time axis. It is also interesting to note how closely the curves for magnesia and kieselguhr follow each other. The magnesia used was of the common powdered variety and is familiar to every one. Kieselguhr, which in English means infusorial earth, is, as the name implies, a fire proof material. Its general appearance is very similar to that of magnesia. It is a dull white, and feels very much like a poor grade of baking flour.

Mineral wool is a tough fibrous material, resembling to a large extent rough wool. It has been the standard heat insulator for fireless cookers for years. E. X. fiber and asbestos cement are both compounds of long fiber asbestos. Both are fireproof.

Fig. 3, which gives the net results of the tests, shows that mineral wool, magnesia, and kieselguhr are the best insulators. Magnesia may be eliminated at once, since its cost is greater than that of kieselguhr and its advantages are not greater. This narrows the field to mineral wool and kieselguhr. Mineral wool has one distinct advantage over kieselguhr. It can be packed around an oven without making the containing box absolutely tight. Mineral wool, due to its fibrous make-up, does not have a tendency to leak through every crack. Kieselguhr will sift through every seam and crevice, and when it is used, all cracks and seams must be closed with stove putty or sodium silicate. Kieselguhr being light and cheap is considered to be the proper insulator for fireless cooker work. The thickness of wall used depends upon the amount of heat that the designer wishes to retain. The thicker the insulation, the smaller the amount of heat that is lost, but the greater the cost of insulation. The happy medium for good fireless cooker work, is between two and one-half inches and three inches. Above three inches, the added cost of insulation overbalances the added efficiency. As an example of the insulating properties of kieselguhr, an oven was heated to 380° F. and at the end of three hours, the oven thermometer recorded 362°, which means an efficiency of approximately 95 per cent. for the three hours' test.

COMMERCIAL ELECTRICITY

I. M. Kirlin, '13

Ten years ago the commercial department of the average central station received little consideration by the directors of the public service companies. New business was handled in the simplest way by inexperienced men with no technical knowledge of what they were selling and what it would be used for. While the business of the central station was taking care of itself, great effort was exerted toward increasing the efficiency of operation of the station, both by the manufacturer and station operator. Rapid developments in highly efficient generating and distributing equipment in the last few years served to arouse the dormant central station business.

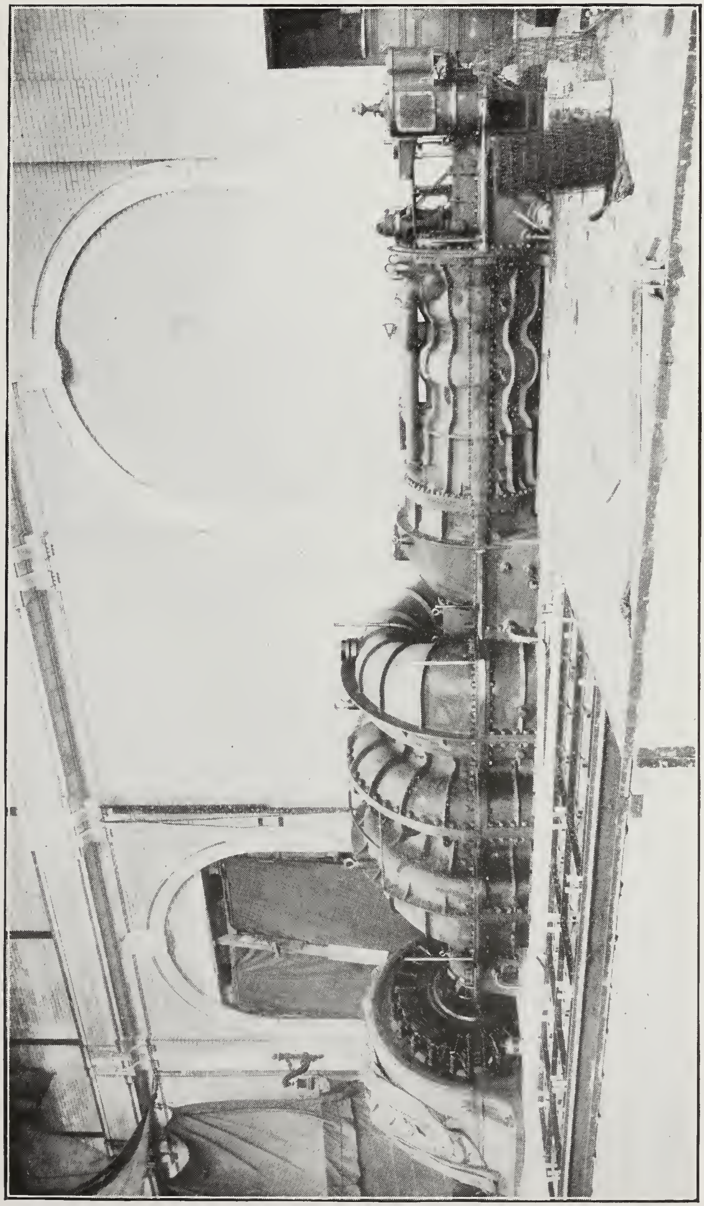
The first promoter to seriously consider the commercial side of the central station business was Mr. Samuel Insull, president of the Commonwealth Edison Co.—the largest central station company in the world—and allied companies capitalized at more than 570 million dollars. The commercial efforts of the Commonwealth Edison and allied companies have resulted in much greater use of household and industrial electrical appliances, a rapid increase in the industrial power load, and increased residential business on existing distribution lines.

The recent inauguration of Public Service Commissions by several states has led to considerable discussion among central station directors. The general opinion of promoters is that these commissions will work to the advantage of both the public service companies and the public served. Some such system was advocated by Mr. Insull twenty-five years ago.

The development of highly efficient turbo-generators, transforming apparatus, and distribution of systems has had so great an effect on the central station business that a system of merchandising electricity has resulted. Generating units of 25 and 30,000 K. V. A. have replaced smaller and less efficient units. Highly efficient transformers and transmission line constructions are serving to stimulate the growth of the centralized generating stations with general transmission to the distributing points or sub-stations. In the rural districts especially, is this latter system rapidly replacing the local generating station. All business of the company is governed by the central office of the system, the operation of the various stations or sub-stations being governed by the "System Operator." From his office all instructions to the local superintendents and the various departments are sent out over private telephone systems. The station, operating transmission lines, often secures a considerable power load by connecting with mines and pumping stations. The transmission line is sometimes tapped where the connected load warrants, to furnish power to farms. Each tap on a high tension line weakens the system, and where continuous service is of great importance taps for small loads are avoided. A duplicate line is frequently run to important rural installations to avoid any interruption of service.

The Commonwealth Edison Company maintains several large installations of storage batteries floating on the line to assure continuity of service, which is being recognized more and more as an essential in securing business for the central station. If all of the generating stations in Chicago went out of service at one time, service would be maintained by reserve storage battery capacity alone for a period of 30 minutes.

The effect of the introduction of tungsten lamps upon the public service company has been a subject for considerable discussion in central station circles. The objection was raised that the higher efficient lamp would reduce the revenue to the Company. Data collected by the National Electric Light Association, however, proves the contrary. Instead of the consumers' bills decreasing, the amount of light used increased to such an extent that the bills were practically the same as before; the illumination greatly improved; and complaints were fewer. Since this investigation, there has been put on the market the latest development in illuminants, the Nitrogen Vapor Lamp, with an efficiency of one-half watt per candle. That this lamp will meet with general approval by public service companies is little doubted, since the report of the investigation on the effect of tungsten lamps. The tungsten lamp enables the central station to compete favorably with gas as to cost, and the nitrogen lamp is expected to deal the gas arc its death blow for commercial lighting.



New Parsons, 25,000 k. v. a. horizontal type unit made in England being installed in Fisk Street Station. The overall length is 54 feet. All auxiliary apparatus is placed beneath it, and is motor driven.

The most important factors to be considered by the commercial department of the service company are the load factor and the diversity factor. The load factor is of prime importance and is defined as the ratio of the average load to maximum load.*

The load factor of the Commonwealth Edison Company is .46. The importance of a high load factor is evident when its effect on the cost of energy is considered. For example, the cost per unit of energy sold may be apportioned as follows—in large stations overhead charges equal 55 per cent and operating charges 45 per cent; in small stations the overhead costs and operating costs per unit of energy sold are nearly equal. Assume a station to have a load factor of .20, which is not uncommon in an undeveloped territory. The cost per unit of energy sold will be taken as 10 cents; one-half of this cost will be charged against overhead expenses including interest on capital invested, depreciation, taxes, etc. The other half or five cents will be the operating cost including cost of fuel, labor, etc., and will be independent of the amount of power sold. If the load factor is increased to .40 without increasing the maximum or peak load on the station, the primary of overhead portion of the cost per unit of the energy will be half as much as in the first case, since the output of the station will have doubled. Assuming the operating cost to remain at five cents per unit of energy, the total unit cost of energy has decreased to seven and a half cents. Thus, not only has the cost of energy to the service company been reduced, but the amount of energy sold has doubled.

The load factor depends largely upon the diversity factor. The ratio of the sum of the maxima of the subdivisions of any part of the system to the coincident maximum demand observed at the point of supply is called the diversity factor of that part of the system. Thus if the sum of the maxima on a group of customers' meters is 60 K. W. and the coincident maximum at the transformer serving them is 20 K. W., the diversity factor between consumers would be 60/20 or 3. The average diversity factor for residence lighting in Chicago is 3.35; for commercial lighting, 1.46; for general power, 1.3. The diversity between transformers on the same feeder is 1.4. At the sub-stations the diversity between feeders averages 1.15. Where there is about 25 per cent. of the light and power load of the city which has a 7:30 p. m. maximum, as in Chicago, the diversity between sub-stations is 1.1. The total diversity of the system is the continued product of the diversity factor between consumers, transformers, feeders and sub-stations. The total diversity factor for the Chicago system for all classes of service, except railway load, is at the present time 2.64. The load factor of all classes of consumers in Chicago is approximately .23, and, due to the diversity from consumer to generating station, the load factor of the system is increased to .46.

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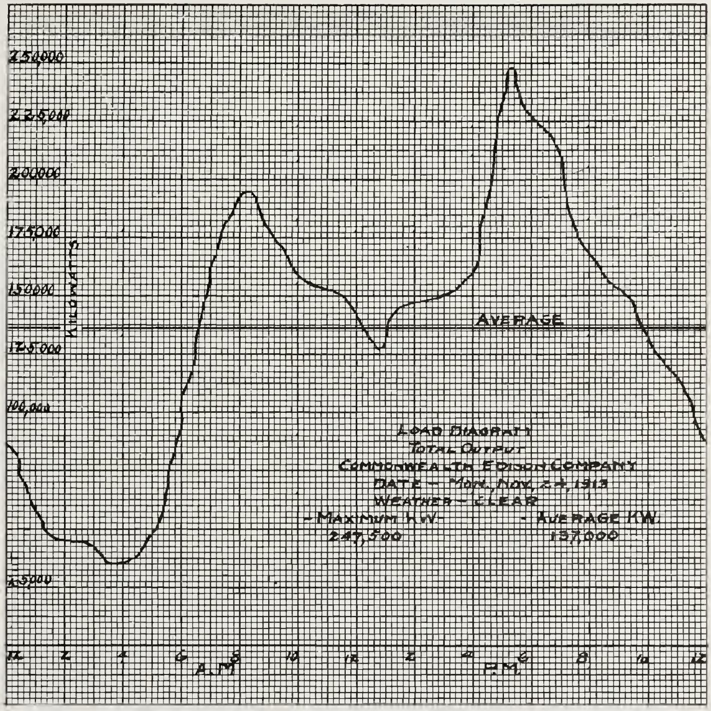
*The National Electric Light Association has defined load factor as the ratio of the average load to the connected load. However, in the next N. E. L. A. Handbook this definition will be changed to consider the maximum instead of the connected load.



Curve Showing Total Load Output of All Stations for an Average Day. Peak at 5:15 due to Railway Load.

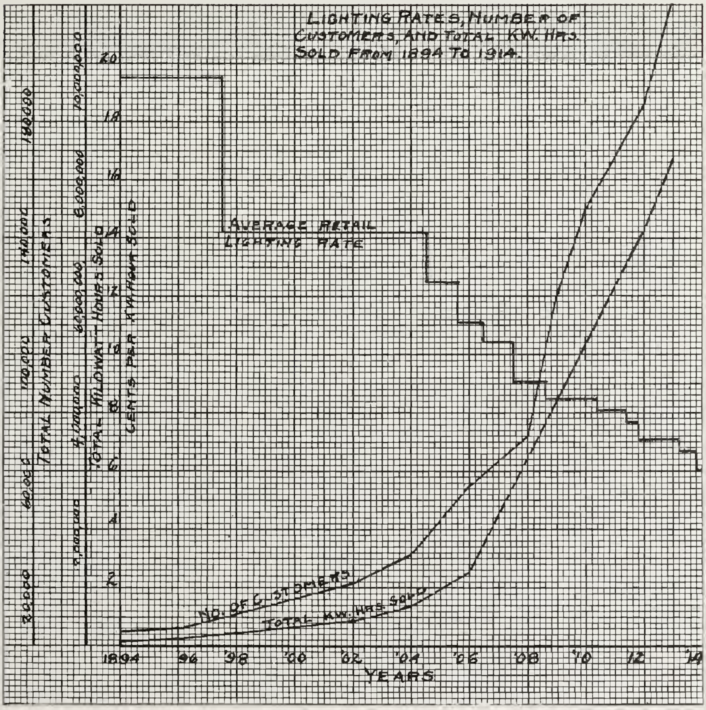
By carefully considering the load factor of the load to be connected, and its diversity with other connected loads, the output of the central station may be increased greatly without increasing station investment.

The fundamental step taken by the new business or commercial department of the central station company is to establish a just rate system. Rates must be charged for any particular class of service in proportion to the cost to the central station of supplying that service. Most large central station companies charge for service according to the Hopkinson and the Wright systems, or a modification of these systems, making use of a double sliding scale of rates both on the consumers' maximum demand and on the K. W. hr. consumption.

Central station business is commonly divided into two main classes, light and power, and subdivided into residence, commercial, and industrial business. To handle the business with the customer, the company employs light salesmen and power salesmen. Each salesman or solicitor is given a particular district with definite limits in which to work, and all calls or applications for light or power which are not taken at the counter or over the telephone, are turned over to him. These salesmen usually receive a salary and commission on the new business secured in their district. The Commonwealth Edison Company at the present time employs 36 light solicitors, two sign solicitors, with several assistants, and 18 power salesmen with four assistant power salesmen. It is the duty of the light solicitor to secure contracts for all kinds of lighting, small power such as fan motors and electric washers, and to give estimates on small wiring jobs of less than six outlets. Larger wiring estimates are handled by the estimating department. A ruling recently passed by the company, requires an applicant for a position as assistant light solicitor, to spend six months in the illuminating department. Of the 18 power salesmen, only 12 have regular assigned districts. The other power men work on special power problems, such as isolated plants, electric vehicles, electric railway, and general power questions.

The contract department works hand in hand with the salesmen in securing new business. Several per cent. of the net earnings of the company are set aside each year for advertising electric service by means of elaborate electric signs, illuminated billboards, street car cards, mail matter, and "ads" printed on the bills submitted by the company. The bulk of this advertising applies to residential business, though good results have been obtained through the use of booklets published by the National Electric Light Association to advertise electric service.

The residential business of the company has been considerably increased through so-called "house wiring campaigns." For several weeks, existing unwired houses on the company's lines are wired at cost. As an added inducement to obtain this business, an electric iron is sometimes given with each contract for wiring obtained during this campaign. The wiring may be paid for in 24 monthly payments and may be done by the central station company or turned over to local contractors. Considerable discussion has arisen on this point and may be most satisfactorily settled in specific localities. Some central station companies report the securing of contracts for as many as 80 per cent. of the available residential buildings through house wiring campaigns.



Curves showing the profitable result to the Commonwealth Edison Co. of systematized commercializing of electricity.

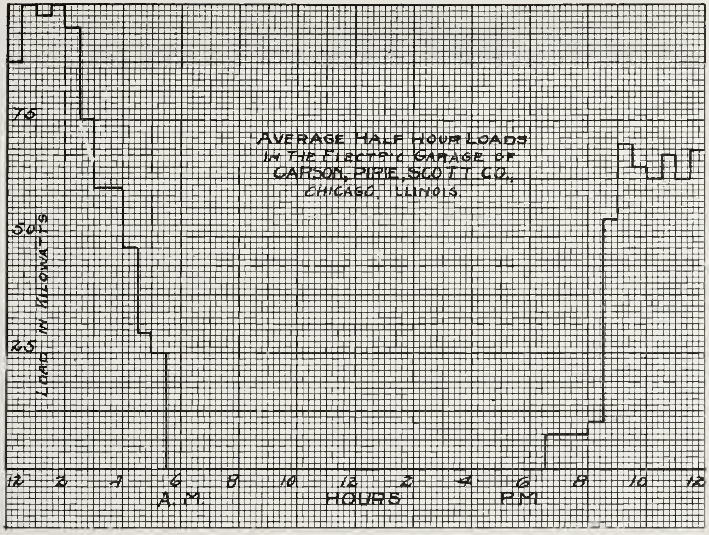
Next in importance to the wiring campaign is the appliance campaign to increase the load factor and total consumption of residential customers. In these campaigns, special emphasis is put on one particular appliance which is most easily introduced, commonly the electric iron. The Commonwealth Edison Company appropriated 15,000 dollars to be used in an electric iron campaign which was launched in March, 1913. As a result of this campaign 12,000 electric irons were put in service in 60 days, and at the present time in Chicago, one out of three residence customers uses an electric iron. The revenue from each iron is approximately 40 cents per month, which is an increase of 20 per cent. in the customers' bill. This spring a campaign on electric percolators will be launched in Chicago.

Before leaving the residential side of the new business, emphasis should be placed upon the importance of a simple method for the residential customer to secure service. It is natural for this type of customer to hesitate to place a contract for service when he feels that there is a great amount of "red tape" connected with it. A simple system employed by the Commonwealth Edison Company in handling this class of customer is to take the application over the telephone and mail the contract to be signed after the service has been connected.

Contracts of various types for commercial lighting, such as small stores, have been put into effect by the Commonwealth Edison Company from time to time. The general principle of using contracts for standard street posts, electric signs and fixtures on a rental basis has worked satisfactorily with small stores, saloons, etc. These contracts usually cover a period of two years to guarantee the Company sufficient revenue to pay for the wiring.

In securing an industrial power load, more complex problems must be handled and the minute details of the load to be connected are considered. Whether or not a particular industrial load is secured for the Company, depends chiefly upon the power salesmen and the rate offered by the Company for that particular class of business. Rates for power are based upon maximum demand, load factor, total consumption, and nature of operation—whether or not the connected load comes on the peak of the Company's load. The power salesmen offering to furnish service to replace an industrial power plant or engine makes a complete analysis of the present installation before submitting a proposition. He knows more nearly what the manufacturer pays for power than the manager himself. The clever salesmen, with a good knowledge of the operating conditions of the industrial plant, usually is able to secure this load for the central station by offering a fair rate and good service.

Large power installations require special rates and often special sub-stations. Considerable data has been collected in the last few years on application of central station service for operating coal mining and ice machinery, irrigation and oil pumps, and air compressors. The important advantage of a vehicle battery load has been noted. Special conditions are met with in each of these applications, and the details of operation and characteristics of the load curves are carefully studied. These investigations have resulted in securing for the central station a large portion of the available business of this nature, especially in the middle west.



One of the most attractive loads for the central station is the ice machinery load. The load is fairly constant and comes on early in the morning to fill in the valley of the station load curve. Another advantage of this class of business is its season diversity with respect to the higher winter load of the station, as its consumption during the summer months is much greater than in winter. Coal mines, irrigation, and oil pumping loads are especially attractive to companies operating a system of transmission lines through rural districts, since long line extensions are not usually necessary to connect the load. The electric service company which has been perhaps most successful in securing an oil pumping load, is the Oklahoma section of the Middle West Utilities Company. The power engineer of this company expects to have secured all the available load of this nature, in the state of Oklahoma, within a few months. The same company now supplies service to several large coal mines in Illinois, and stone quarries in Indiana.

The electric garage business is at the present time commanding considerable attention from the power engineers of all large public service companies. This class of business has been given little consideration and, due to the efforts of the electric vehicle manufacturers, has increased until it promises to be one of the most important loads a station may secure. The electric vehicle is used not only for pleasure, but also for trucking purposes. This load is perhaps more attractive to the central station than the railway load, since the batteries may be charged on an off peak schedule and thereby raise the station load factor. Chicago leads every other city in the world in the number of electric vehicles. Two prominent department stores in the city use respectively 158 and 59 electric trucks for delivery purposes. Practically all the trucking for the Commonwealth Edison Company is done with electric trucks. On January 1st, 1914, there were 702 electric commercial trucks in service in Chicago, and nearly 3,000 passenger vehicles. Electric heating appliances for industrial purposes are coming into general use, also, especially electric glue pots, welders, and furnaces. The use of these appliances promises to become as general as the common electric household appliances.

In this article, I have outlined in a general way, the problems that confront the commercial or contract department of a large central station company. A systematic study of these problems, such as has been and is being made by the various large central stations is certain to bring results. That the results obtained by the Commonwealth Edison and allied companies have been strictly satisfactory is shown by the accompanying curves.

THE CYCLECAR

H. A. Huebotter, '12

Economy in maintenance and operation of the motor car is a characteristic which prospective owners are demanding more and more insistently of automobile manufacturers. This same demand has been heard in Europe for years, owing to the exorbitant price of fuel existing there. When gasoline sells at $1.02 per gallon, as it did in England in 1912, the average motorist requires that one gallon carry him farther than the ridiculously low distance of 12 miles as is a fair average in America. Judging from the indications of the past two years similar fuel conditions will soon be approached in the United States. The rising cost of gasoline has been offset in Europe by an increased efficiency of the car. In average commercial car practice the vehicle weight is very close to the carrying capacity. The ordinary two passenger roadster of America weighs anywhere from 1500 to 3700 pounds and provides transportation for a load of 300 to 400 pounds exclusive of equipment. This means that 80 per cent. or more of the fuel is spent in moving the bare car and the cost per passenger mile appears enormous. European designers have reduced the rate of car weight to load in order to cut the overhead cost of running. The change has been accomplished gradually—so gradually as to occasion great comment in neither Europe nor America. The general trend of the current automobile design was followed and the small car slowly developed from the large one. In France, however, one designer worked out an original idea and the Bedeha was created. The newspapers and journals exploited it as a freak and a joke and spread the news of the first cyclecar throughout the country. The machine was propelled by a "V" type twin-cylinder, air-cooled motor set longitudinally in the frame. The power was transmitted through a single chain to a jackshaft, thence to the rear wheels by "V" belts. Steering was by hand wheel through shaft, bobbin, and cable to a pivoted front axle. Tandem seating with narrow tread completed the unique features of the design. The car showed speed, reliability, comfort and economy, and became popular. It was copied and developed and took the name of cyclecar.

But what is a cyclecar? What is there about it to distinguish it from an automobile? The European cyclecar is limited in piston displacement to 1100 c.c. (67 cu. in.) and in chassis weight to 672 pounds. It may have either three or four wheels. These restrictions as to cylinder capacity and car weight do not apply in the United States and a revision of the definition is now under discussion in England. At the first meeting of the Cyclecar Manufacturers' National Association held in Chicago January 27, 1914, a classification was adopted in order to show each manufacturer his standing in the cyclecar world. Under this ruling the cyclecar is a four wheeled vehicle of which the maximum piston displacement is 71 cu. in. and the maximum total weight with tanks empty is 750 pounds. The light car class includes those machines with a motor capacity of 71 to 100 cu. in., and a weight of 750 to 950 pounds. The small car has a 100 to 125 cu. in. motor and a weight of 950 to 1150 pounds. This largest car is far below the present small automobile in size. Nothing has been decided yet as to general standards of tread, seating capacity and arrangement, or design of any description. The indications at present, however, are that the cyclecar class will be composed of cars fitted with air-cooled motors of nearly maximum size, friction or planetary change-speed gear and probably belt drive. The true cyclecar obviously should be built as simple as possible compatible with safe and effective performance. In the cyclecar the effort has been made to combine the best features of both the automobile and the motorcycle, in a four wheeled, two passenger vehicle. Some designers have started with the automobile, others with the motorcycle; still others have begun with the intention of building a car light, simple, fast, safe, comfortable, economical and reliable, have selected such parts of the automobile and the motorcycle as would best meet their requirements and have combined them in conjunction with parts peculiar to their own creations.

In the matter of expense, both initial and operating, the cyclecar is far lower than the average small automobile and but slightly higher than the motorcycle. Gasoline consumption runs about one gallon for 35 to 40 miles. Tire cost is low, standard motorcycle tires being the usual equipment, of which the full set can be obtained at a price below the ordinary touring car case. The wear on the tires is slight, for a cyclecar with the 28 inch by 2½ inch size is overtired. A cyclecar, to be satisfactory, must possess several features to a degree at least as great as the automobile. The machine being new, will be subjected to criticism and tests more severe than that accorded the big car. The first impression being the most important, the car should have, first of all, a good appearance with racy lines so universally sought in this type. It should look comfortable, sociable, sturdy and safe, and, above all, finished. The machine having created a favorable first impression must be capable of supporting it in performance. It must show speed with easy riding and must be quiet both in exhaust and in moving parts. In order to be economical in operation as well as to have the desired speed, the weight should be reduced to the minimum consistent with strength. The motive power should be properly proportioned, for if excessive the fuel consumption will rise quickly and the various parts may be overstressed. The most desired quality, reliability, should always be borne in mind by the designer, the manufacturer and the purchaser. Without this essential element the low priced car may prove expensive in the end and is sure to be a constant source of annoyance to the owner and the dealer as well as of danger to the passengers.

That the cyclecar has two fields to enter has already been demonstrated. As a pleasure car for two it is ideal. It can travel roads and enter places impassible to the touring car; it can take bad turns, highly cambered, slippery surface, and short choppy bumps at a speed and with a degree of comfort and safety altogether foreign to the auto. For short trips of a single day's duration it is unsurpassed and it is also applicable for touring so far as comfort and road performance are concerned, but the baggage space is necessarily somewhat limited. As a commercial vehicle the cyclecar is filling a long felt want in light package delivery requiring a capacity of 250 to 300 pounds. It is handled well in city traffic, is quicker than any other means used in similar service, and the operating cost is almost negligible. It is by no means a fair weather car, but may be used under all conditions favorable to motor cars. It is especially successful in rainy weather on pavement, for it does not skid on the most slippery asphalt.

The cyclecar of the present is represented by nearly as many different types as there are manufacturers. The endeavor has been to adapt the car to American tastes and American roads. Just how these tastes will be best satisfied is a question of many sides. One thing is certain, European designs will never be popular in the United States. The foreign big car with an appearance that appeals to the average American is a rarity. For this reason the first season will bring forth machines of every description. It will be a period of experiment in exterior design. The cyclecar to date has not a single standard and the establishing of standards will probably be attended with difficulties at the outset.

In the matter of power plants the cyclecar has a choice of about as many general forms as the automobile and the motorcycle combined. On account of light weight requirements the motor is of the high speed type. The true cyclecar will in all probability be equipped with a two cylinder motor, the light car and the small car with a four cylinder. The latter is pretty well standardized from its development with the automobile. The cyclecar on the other hand offers a large field for the various twin cylinder designs. The motor may be of either vertical, horizontal, or "V" type, hung longitudinally or transversely. Of the two cylinder vertical motor, two kinds have been tried out on the early automobiles. That in which both crank pins are on the same side of center has good firing balance but poor running balance. The cycles in each cylinder are one revolution apart, but the reciprocating and the eccentric rotating parts can be balanced through but a small range of speed. Cranks on opposite sides give an improvement in the running, but the cycles occur at unequal intervals—180 degrees and 540 degrees apart. On account of these defects this motor has been abandoned almost entirely in the automobile industry. The twin with the least vibration is the opposed type. The cycles occur one revolution apart and the reciprocating parts, working in opposite directions, set up forces which neutralize one another. Practically all of the vibration is due to the explosions. The chief objection to the opposed motor is its width. The narrow frame of the machine renders transverse hanging difficult. With longitudinal setting the force of each explosion tends either to retard or to accelerate the car, depending upon which cylinder is firing.

The twin "V" bids fair to become the favored two cylinder motor. It is short with a single throw crank and consequently less eccentric weight than the vertical motor.

As ordinarily constructed the cylinders are set at an angle of 45 degrees, but 60 degree and 90 degree angles are not uncommon. The first arrangement is the most compact and has the best firing balance of the three. The last is better balanced kinetically than the others, but fires at intervals of too great variance. It is wide in comparison with the 45 degree motor and has a long inlet pipe, a serious objection in cold weather. The 60 degree motor is a compromise between the two. The firing order of the 45 degree type is 0 degrees, 315 degrees, 720 degrees; of the 60 degree, 0 degrees, 300 degrees, 720 degrees; of the 90 degree, 0 degrees, 270 degrees, 720 degrees. The "V" motors have been well tested and developed in connection with the motorcycle industry, and it was at first thought that the same motor would be equally satisfactory in the cyclecar. The error of this opinion was soon demonstrated. A four wheeled vehicle is expected to travel more slowly on occasion than one on two wheels, and that without changing gears. Consequently the cyclecar motor must contain heavier crank disks to enable it to operate successfully at low speeds. The car puts a much heavier torque upon its motor than does the motorcycle in accelerating. For this reason a comparatively stiff crankshaft is required and rigid connections of the shafts to the disks are essential. A motor which will drive a motorcycle through a plain taper fit of the shaft in the disk will easily shear a 7/32 inch key, augmenting the same fit in a cyclecar.

This heavy torque renders the air cooling proposition more complicated with the cyclecar. A fan with free circulation of air must be provided. The usual form of air cooling without jackets is not likely to be practicable with any but the "V" motor. Four cylinders, even with the best air jackets and forced draft, have a decided tendency to overheat as has been proved conclusively in automobile practice. The water cooled four cylinder motor has the greater popularity and will in probability keep it, unless radical improvements are made with the air. The experience of the early motor car manufacturers offers much of value to cyclecar designers.

In the ignition system the cyclecar was found again to break away from motorcycle precedents and teachings. Since the "V" motor fires at unequal intervals the high tension magneto, if used, must be geared to half crankshaft speed. For this reason the motor will not run well at low speeds since the spark is not sufficient to fire the mixture. Besides the low speed is the fact that the interrupter cannot break contact at the point of highest voltage for both cylinders. The error is split between the two cylinders, making one fire 22½ degrees before, the other 22½ degrees after the ideal point, measured on the armature travel. This reduces the voltage approximately 30 per cent. and, combined with the gear reduction, gives poor ignition for starting and slow running. The usual arrangement for cranking the motor on the magneto by hand is the provision of a two or three to one gear between the starting crank and the crankshaft in order to obtain sufficient speed for a spark. By far the most common type of ignition for this motor is by high tension battery system with non-vibrating coil. The same device is usually fitted to the small four cylinder also, although here the magneto is perfectly feasible.

The speed and torque control of the cyclecar is provided for in the same ways as used in the automobile. In the former, however, the friction drive leads in popularity on account of its simplicity, absence of noise, and its smooth action. The power transmitted is not great enough to require frictions of excessive diameter and the chief objection to this drive is therefore overcome. The danger of rapid wear due to overloading is absent and the possibility of selecting the exact gear ratio required to drive the car over any road encountered appeals to the careful operator. The friction may be located in one of two places—either ahead of the dash next to the motor or under the seat. Both places have their advantages, as will be brought out later. The sliding gear and the planetary transmissions have been adopted by some manufacturers. The former is used principally with the four cylinder motor. The planetary gear has always carried the objection to the noise produced by the pinions rotating at the high speed required. This is especially noticeable in the cyclecar where the high speed motor is the rule. Either of these transmissions may be placed in a housing bolted to the motor or to the rear axle or carried between the two.

The drive from the change speed gear to the rear wheels is usually one of three standard types—chain, shaft or belt. The first is not common in the United States, but has met with considerable success in England where the single chain adherents are strong. The shaft drive is used in conjunction with the sliding and the planetary transmissions. It connects with the live rear axle through two bevel gears or worm and worm wheel. The cars fitted with the final shaft drive are practically all out of the cyclecar class. The transmission most popular among cyclecar designers is the double "V" belt from a jackshaft to each rear wheel. This gives a flexible connection to the wheels and thus saves the tires from the strains occasioned at times by a positive drive. A wide difference of opinion exists regarding the correct method of applying the belts. Some designers favor a long distance between pulley centers in order to secure a large arc of contact on the driving pulley. Others prefer the short belt to eliminate sideslap and vibration. The belt has demonstrated its practicability under the most adverse road conditions in water, mud, snow and dust. The ordinary leather belt must be driven about 100 miles before the stretch is all out of it, but the non-stretchable type in which two strands of steel cable are built into the belt between two plies of leather seems to have overcome this objection. Other belting materials which have been used with more or less success are rubber covered canvas and steel chains lined with friction fabric. With the use of the double "V" belts the differential is dispensed with, giving greater simplicity.

The steering of the early cyclecars was through bobbin and steel cable. This arrangement was simple, effective and reliable, but the general public showed such distrust in the device that it was discarded for some one of the standard automobile types. The rack and pinion gear predominates, although the worm and sector is very nearly as popular. The Ackerman linkage to the front axle is used almost exclusively, except in the few rare instances in which the front axle is pivoted in the center.

The riding qualities are dependent largely upon the spring system. The cyclecar is often fitted with springs of design peculiar to itself, but standard automobile suspensions are more popular at present. This is probably due to the fact that these types have been tested so long that the public has confidence in them. Of the various systems the full elliptic, three-quarter elliptic, semi-elliptic, and cantilever are all in use. The cyclecar springs of special design are of simpler construction and include the helical and the transverse springs. The latter may be swung over the axle or it may be used as a substitute for the axle. Whatever the shape, the springs must have clearance to permit of the use of a light scale. A flexible spring with little unsprung weight allows the wheels to take sudden jars without affecting the motion of the body. It is this feature that enables the cyclecar to run away from the automobile on a corduroy road.

The seating arrangement depends largely upon the opinions of the designer. The tandem method gives slightly better balance with one passenger in the car than does the side-by-side. The difference, however, is not noticeable to the occupant. This doubtful advantage is offset by the greater sociability attendant upon the latter plan which seems to be favored by general opinion. Staggered seating, which is not widely adopted, is a compromise between the two. The method of seating naturally determines the width of the body which in turn influences the tread. Thus, unlike the automobile, the cyclecar is built with a diversity of treads. The same condition prevails in Europe, but there the highways are so improved that there is no reason for following the beaten tracks as is the custom in America. Here the aim is to adopt a tread that will allow one wheel to take the wagon track and the other the horse track. This condition is best met by a tread of 36 to 40 inches.

ALTERNATOR REGULATION

D. Linder Curtner, '11

If the load on an alternator is increased, while the speed and excitation are maintained constant, the terminal voltage will in general decrease. Conversely, when the load on the alternator is reduced the terminal voltage will, in general, rise. The rise in voltage, when full non-inductive load is reduced suddenly to no-load, expressed as a per cent. of full load voltage is called the inherent regulation of the machine, with constant speed and full load excitation maintained. The predetermination of the impedance drop, armature reaction, voltage regulation, and field excitation at various loads and power factors from the dimensions of the machine falls under a single head and constitutes a very important problem in alternator design.

After the alternator is built it is not always possible to test it accurately at the factory, principally because of the difficulties of driving, loading, cost of such testing, and the modern tendency toward large units direct connected to the prime mover. Very frequently the alternator and prime mover are built by different companies and are brought together only when installed in the generating station, where the facilities for accurate testing are not always favorable. For the above reasons the testing at the factory usually consists of taking the open circuit characteristic or saturation curve, the short circuit characteristic, a heat run, and measurements of resistance of the windings.

The saturation curve may be readily calculated from the dimensions of the magnetic circuit, the flux density, and the B-H curves of the materials used. In predicting voltage regulation, we are principally concerned with the excitation required for the air gap, teeth, and slotted portion of the magnetic circuit, since the magnetomotive force required for the pole shoes, pole cores and yoke is not effective in forcing flux into the armature but is effective only in overcoming the magnetic potential drop in the above mentioned parts. The ampere turns required for the air gap may be calculated by determining the permeance and flux of corresponding areas. Thus one may select a slot pitch as the area, at the center of the pole. Let

$P_3 = \frac{1}{2}$ air duct permeance
$P_1 =$ permeance from tooth top to pole
$D =$ air duct width
$P_2 = \frac{1}{2}$ slot permeance
$P = P_1 + 2\,P_2 + 2\,P_3 =$ permeance per slot pitch
$\delta =$ air gap length
$s =$ slot width
$t =$ tooth width
$l_n =$ net axial length of armature
$n =$ number of air ducts

Remembering that permeance is the reciprocal of reluctance, one may write the following equations:

$$P_1 = \frac{t\,l_n}{\delta}$$

$$2\,P_2 = \frac{4\,l_n}{\pi} \log e \left[\frac{\pi\,s + 4\delta}{4\,\delta}\right]$$

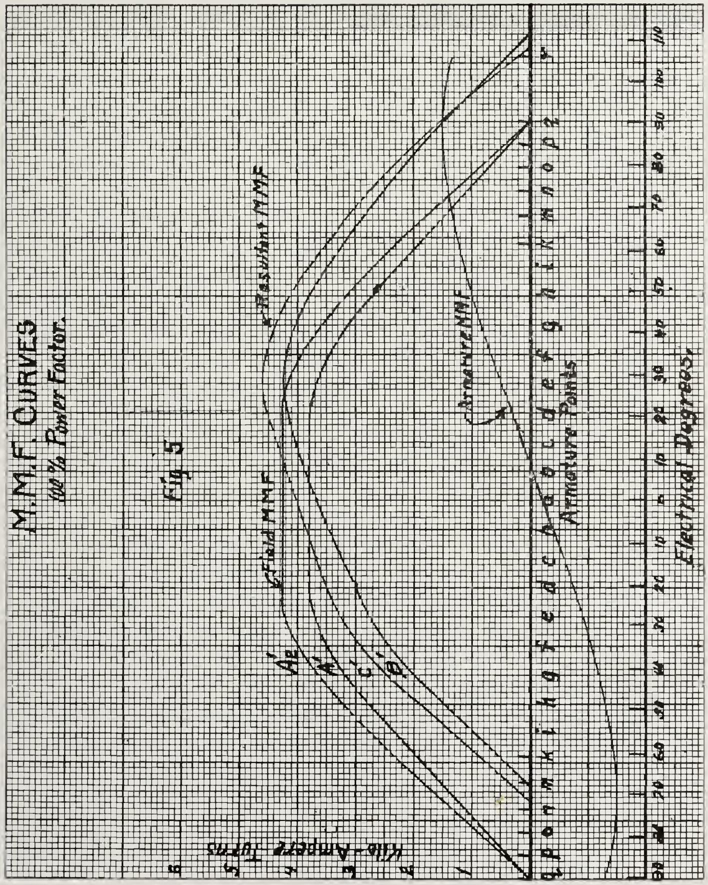
$$2\,P_3 = \frac{4\,n\,t}{\pi} \log e \left[\frac{\pi\,D + 4\,\delta}{4\,\delta}\right]$$

$$P = \frac{t\,l_n}{\pi} + \frac{4\,l_n}{\pi} \log e \left[\frac{\pi\,s + 4\,\delta}{4\,\delta}\right] + \frac{4\,n\,t}{\pi} \log e \left[\frac{\pi\,D + 4\,\delta}{4\,\delta}\right]$$

Considering that the flux passing a given area (in this case a slot pitch) is expressed by $\phi =$ m.m.f. P, or $\phi = .4\,\pi\,NI\,P$, it is relatively easy to show that the ampere turns (NI) required for the air gap at the center of the pole face where the lines of force are sensibly parallel are expressed by

$$NI = \frac{\phi}{.4\,\pi\,P} = \frac{B\,A}{.4\,\pi\,P} = B\,K,$$

Where B is air gap density, $A =$ area of a slot pitch, and $K =$ the constant $\frac{A}{.4\,\pi\,P}$. By the use of this expression it is easy to calculate the air gap ampere turns required at any air gap density. It is also equally plain that a curve plotted between NI and B will be a straight line. The calculation of the excitation required for the teeth and slots is so obvious, since it follows from the expression $Hl = .4\pi NI$, the radial length of tooth l, and readings taken from the B-H curve of the material, that more detail will not be given it here. The sum of the excitation required for the air gap,



and teeth and slots plotted as abscissae against air gap density or generated voltage as ordinate gives the saturation curve desired. The air gap permeance is not constant from all portions of pole to armature but varies according to pole shaping and dimensions.

The drop in voltage caused by the flow of current in the armature conductors may be divided under two heads—

(a) The impedance drop, made up of the resistance and reactance drops,

(b) The armature reaction or neutralizing effect of the armature ampere turns upon the field ampere turns.

The magnitude and effect of the impedance drop varies with the load and power factor of the load on the machine. At unity power factor operation, the resistance drop is the predominating factor, but as the power factor reduces, the reactance becomes of more importance. The resistance, being a function of the cross-section and length of the conductor, as well as the temperature at which it operates, is easily calculated. The reactance is directly proportional to the inductance of the machine. The general scheme for calculating the inductance of the armature winding may be outlined as follows. Divide the winding into the imbedded and end connection portions. Calculate the flux linkage of the end connections per pole per phase by using the transmission line formula between appropriate limits. Calculate the flux linkage per pole per phase of the imbedded portion produced by the flux passing across the slot and also that due to the average flux passing from tooth top to tooth top. The sum of these flux linkages per ampere of current multiplied by the number of poles and divided by 10^8 gives the coefficient of inductance per phase in Henries. Such modifications as are necessary to adapt this general scheme to the case in hand are always permissible.

The magnitude and neutralizing effect of the armature ampere turns also varies with the load, on the assumption that the voltage remains constant and current varies, and the power factor of the load on the alternator. This leads to the calculation of the magnitude, and to the determination of the position of the armature m.m.f relative to the field m.m.f. The m.m.f. of a loop of wire is always perpendicular to the plane of the loop, or if the turns do not all lie in the same plane, the m.m.f. will be perpendicular to the resultant of the group of turns. The voltage of rotation will be a maximum where the flux is a maximum. Hence if the voltage and current waves be assumed sinusoidal and in phase, the maximum will occur when the coil is passing the center of the pole, and O B in Fig. 4 indicates the direction of the armature m.m.f. of phase No. 1. Thus if the current is in phase with the voltage, the m.m.f. of the coil is 90° out of phase with the voltage of revolution, and also 90° out of phase with the field m.m.f. In this position it will be noted that the armature reaction is entirely distorting in its action. When the plane of the coil is at right angles to the field, the current in the armature conductor is zero, hence when in position to demagnetize the field, the armature m.m.f. is zero. With power factors other than unity the maximum of the voltage and current waves does not occur at the same instant, so that with lagging current, the position of the armature m.m.f. will be 90° plus the power factor angle out of phase with the field m.m.f. as shown in Fig. 8, and for leading current the phase angle between field and armature m.m.f. will be 90° minus the power factor angle. The magnetizing or demagnetizing effect of the armature m.m.f. is much greater, as is evidenced by a comparison of Fig. 5 and Fig. 8.

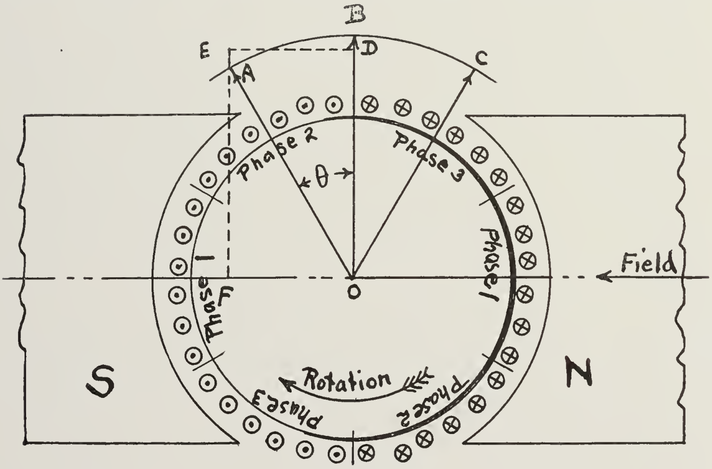


Fig. #4.

It is desirable to know the shape and magnitude of the armature m.m.f. Let the discussion here be limited to a three phase alternator and for simplicity of demonstration choose a two pole machine.

Since the winding of one phase of a three phase machine is spread out over $\frac{\pi}{3}$ electrical degrees, it becomes necessary to sum up the components of field due to each turn into a common direction, OB, Fig. 4. Reducing the calculations to the armature ampere turns per pole in terms of one phase the procedure is as follows:

Let T = turns per pole per phase = OB

$$\text{Area AOB} = \int_0^T \int_0^{\pi/6} P\ d\ P\ d\ \theta = \frac{T^2\,\pi}{12}$$

$$\text{Area AOF} = \frac{T^2}{2}\left[\sin\frac{\pi}{3}\ \text{Cos}\ \frac{\pi}{3}\right] = .2165\ T^2$$

$$\text{OF} = T\ \text{Cos}\ 60^\circ = .5\ T$$

$$\frac{\text{Area AOB} + \text{Area AOF}}{\text{OF}} = \text{OD} = \frac{\frac{T^2\,\pi}{12} + .2165\ T^2}{-5\ T} = \cdot955\ T,$$

which is the summation of the projections of OA on OB as θ varied from $\frac{\pi}{6}$ to zero. If the current wave is sinusoidal the instantaneous value is

$$i = I_m \sin \alpha$$

where i is any instantaneous current valve, I_m is the maximum current value and α is the electrical angle. Then the summation of the armature ampere turns for phase No. 1 at any instant is,

$$NI_{1a} = \cdot955\ TI_m \sin \alpha$$

A similar expression will suffice for phases No. 2 and No. 3 if to α is added the angular difference between the phases. Then for phase No. 2,

$$NI_{2a} = .955\ TI_m \sin(\alpha + 60)$$

and phase No. 3,

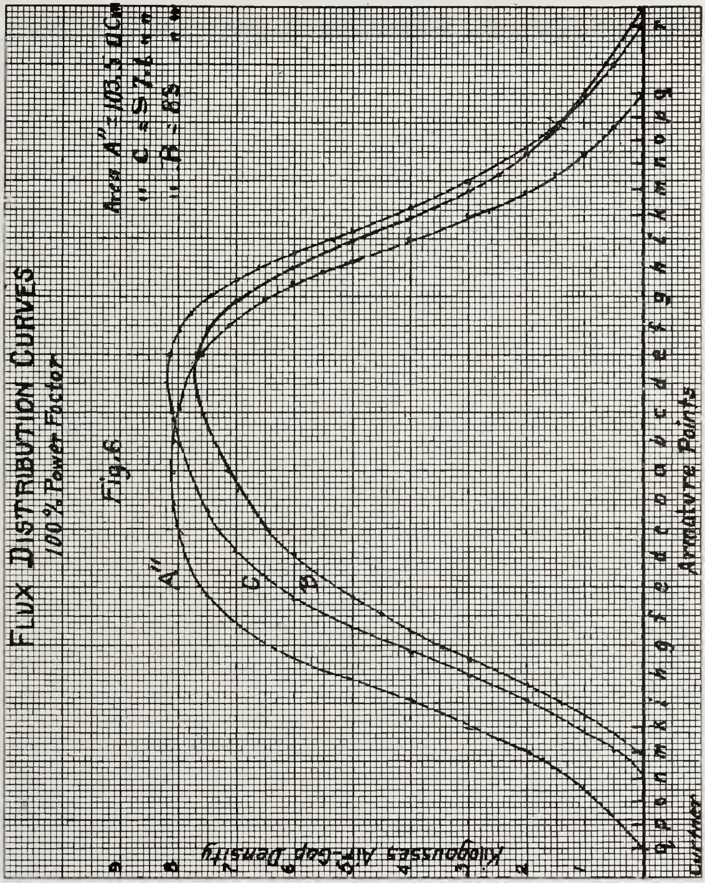
$$NI_{3a} = .955\ TI_m \sin(\alpha - 60)$$

Adding and simplifying the expressions for phases No. 1, No. 2, and No. 3, the armature ampere turns per pole are,

$$NI_{ta} = (2)\ (.955\ TI_m \sin \alpha)$$

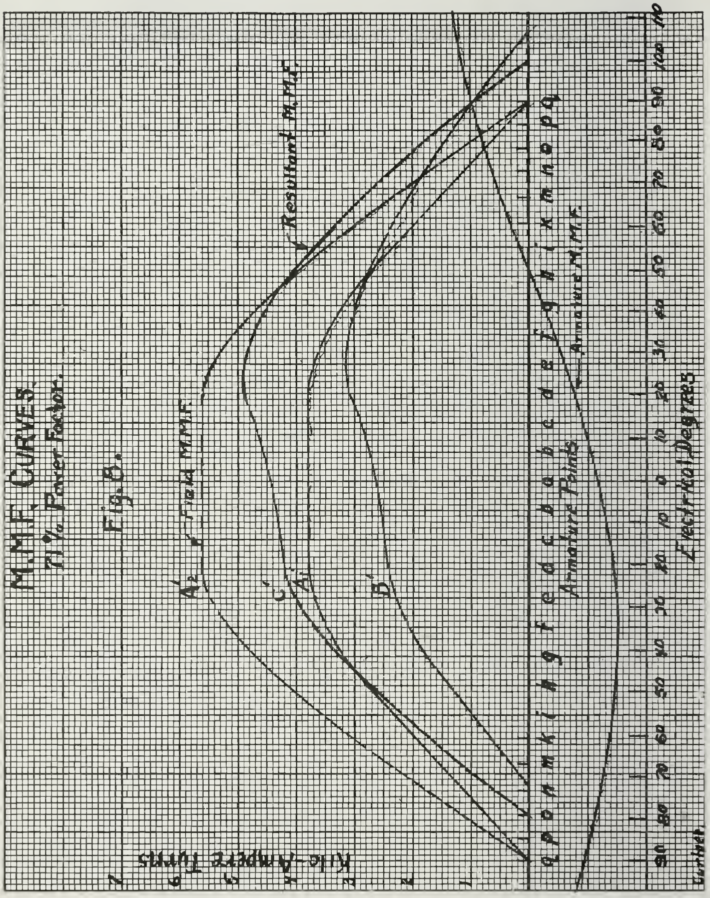
Under these conditions it is shown that the curve of armature m.m.f. obeys a sine law and is of the magnitude indicated by the equation. A similar development of machines of any number of phases results only in a change in the constant (2) (.955).

The magnetomotive force of the field must be sufficient to neutralize the effect of armature reaction and also set up flux entering the armature in amount proportional to the generated voltage, if the speed is to be maintained constant. The amount of distortion and demagnetization or magnetization caused is proportional to the relative strengths of the field and armature m.m.f., the power factor of operation, and the degree of saturation of the armature teeth. This is shown to a marked degree by the comparison of the areas of curve B (69.4 sq. cm.), Fig. 9, where the power factor is .71, and curve B (89 sq. cm.), Fig. 6, where the power

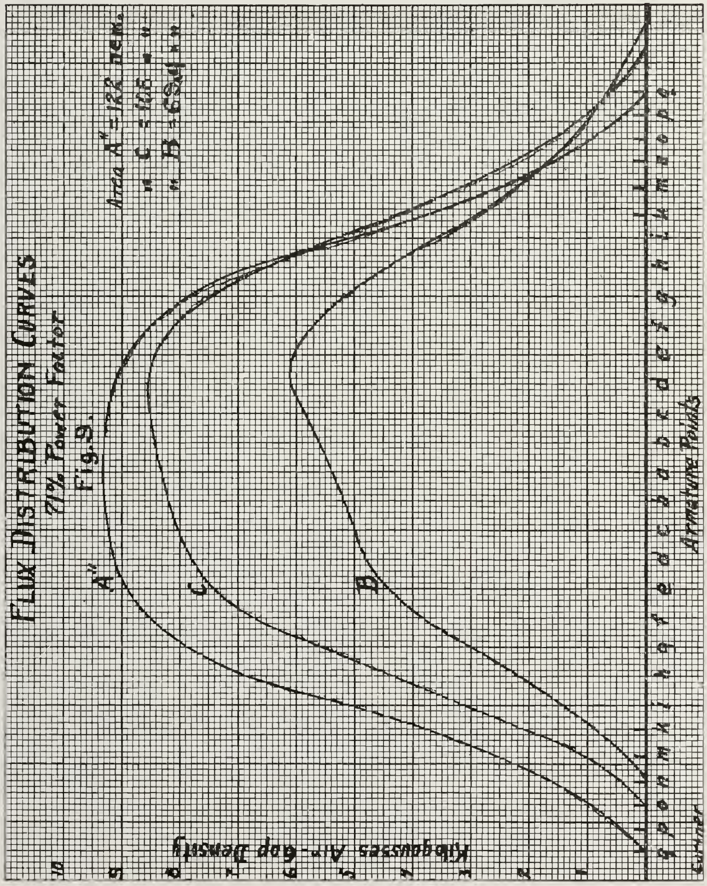


factor is unity, also by comparison of the B′ m.m.f. curves, Fig. 8 and Fig. 5, for the above B curves respectively.

A concrete example of a 300 kv.a., 200 r.p.m., 36 pole, 2200 volt, 60 cycle, 3 phase, Y connected alternator will probably serve to elucidate the foregoing abstract discussion.



The no load and full load (unity P. F.) excitation per pole required for the air gap teeth and slots is 3800 and 4250 ampere turns respectively, (see Fig. 5), and the armature ampere turns per pole, maximum, is 150. From the m.m.f. curves C′ and A'_2, are plotted the flux curves C″ and A″ respectively, representing the air gap flux distribution at full load (unity power factor), and a no load flux distribution when full load field is maintained. From the flux curves, just mentioned, the voltage waves may be plotted in polar coördinates, the measurements of which permit the


FLUX DISTRIBUTION CURVES
71% Power Factor
Fig. 9.

finding of the effective value, the calibration, and hence the regulation. From these voltage curves it is found that the effective value of A″ is 1366 volts, while the effective voltage of C″ is 1310 volts. The impedance drop is 40 volts, leaving a terminal voltage of 1270 volts per phase. The regulation at once follows as $\frac{(1366 - 1270)\,100}{1270} = 7.56$ per cent.

Similarly from Fig. 8, Fig. 9, and the voltage wave for .71 power factor we obtain the regulation at .71 p.f. to be $\frac{(1590 - 1270)\ 100}{1270} = 25.2$ per cent. The results of test data give the regulation at unity p.f. as 7.5 per cent., while the test data for .71 p.f. is not available.

This method of calculating voltage regulation which utilizes the voltage wave shape as it exists, may be applied to either freak or standard designs, since it is calculated entirely from design data. The results conform reasonably close to those obtained in actual tests.

POINTS OF INTEREST DURING THE CONSTRUCTION PERIOD OF THE PANAMA-PACIFIC INTERNATIONAL EXPOSITION

C. H. MUNSON, '11

The Panama-Pacific International Exposition Company was organized by a number of public spirited citizens of the city of San Francisco for the purpose of celebrating the completion of the Panama Canal, an engineering achievement well worthy of some fitting demonstration such as an international exposition. It is the purpose of this paper to give to those interested in engineering and construction work a resume of the various features of interest entering into the activities of the division of works of this company during the pre-exposition period, together with a more detailed analysis and comparison of some of the construction methods in use.

The division of works, which is responsible for the design and installation of all features of construction, is divided for organization purposes into seven major departments—the department of construction, the department of civil engineering, the department of mechanical engineering, the department of landscape engineering, the department of architecture, the department of color and decoration, and the department of sculpture. These various departments each have immediate charge of work pertaining to the planning and development of the special work alloted to them.

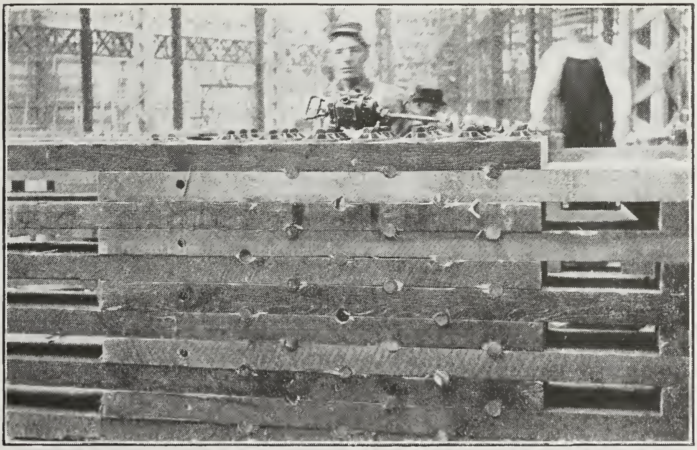
In addition to the above major subdivisions there have been created a number of bureaus for the systematic prosecution of the various parts of the work. Among these are the following which have to do particularly with the various details entering into the engineering design and construction activities. The bureau of structural engineering, is responsible for the design and preparation of plans for all structural features; the bureau of building construction, has direct charge of all building construction, directs building inspectors in their duties and makes up monthly estimates of work completed, on which basis progress payments are made; the bureau of estimates, in charge of the writer, has direct charge of preparing all preliminary estimates of cost of proposed structures and also final estimates of cost of the various structures from the final plans as sent out for bids. A more exact statement of the activities of this bureau is given elsewhere in this article; the bureau of specifications, is responsible for the general form and standardization of all specifications; the bureau of engineering construction, handles the force account, establishes grades, makes necessary surveys, etc.; the bureau of water supply and fire protection, has charge of fire protection measures,

Typical Framing of Machinery Hall. Taken Oct. 28, 1913.

and is responsible for the design and installation of high and low pressure water systems.

In addition to the above there are a number of bureaus which are important, but having a less direct connection with the actual engineering and construction operations, will be only mentioned herein as follows: The bureau of railways, the bureau of illumination, and the bureau of design.

After considerable deliberation on the part of the exposition officials they selected the "Harbor View" lands as the site on which to build the exposition. In conjunction with these lands there will also be used a certain portion of the Presido Fort Mason Military Reservation. These lands front on the bay and afford an exceptional view of the bay and surrounding land. The maximum height of the site selected is 82 feet above sea level, though most of the land is flat. On three sides the site is backed by high hills, which in themselves have caused no end of talk and discussion regarding transportation facilities during the exposition period.



Typical Splice in Main Truss Supporting Dome of Palace of Education.

The preparation of the selected site for the commencing of building construction was in itself no small undertaking, since there were required about 1,700,000 cubic yards of fill. This fill was accomplished by hydraulic dredges at a cost of 301,000 dollars. As the main portion of the buildings erected by the Exposition Company are located on this fill it has been necessary to use piles for the main foundations throughout, and four of the main buildings have their floors supported on piles.

The major portion of the buildings will be of timber construction, although a few will be framed in steel. The construction of the buildings will require the use of about 70,000,000 feet of lumber. In order to standardize the work of design, the following table of allowable stresses for timber was issued to all designers.

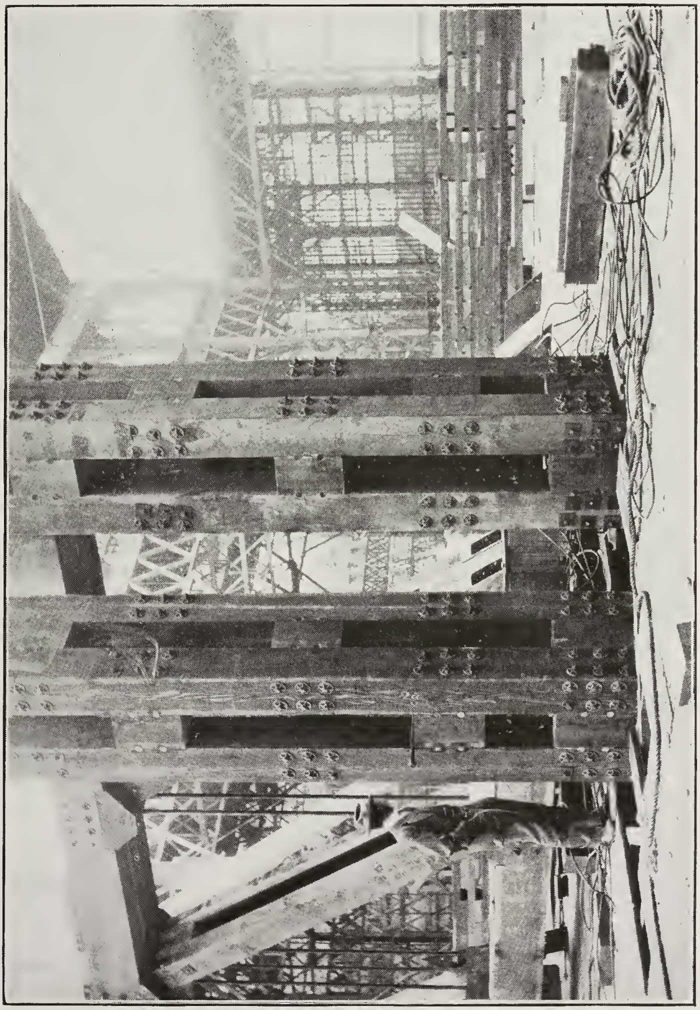
(FOR DOUGLAS FIR)

End compression	1600 lbs. per sq. in.
Compression across fibre	350 lbs. per sq. in.
Shear parallel to grain	150 lbs. per sq. in.
Tension	1200 lbs. per sq. in.
Bending-transverse fibre	1500 lbs. per sq. in.
Columns	p-1600 (1-1/60 L/D)

The wind loads used in design on walls under 150 feet in height were taken at 20 lbs. per sq. ft. of exposed surface; on interior courts, 10 lbs. per sq. ft.; on roofs, 30 lbs. per sq. ft. in a horizontal direction, and for sloping roofs reduced by Duchemin's formula. The stresses in steel members were taken according to Ketchum's "Mill Buildings" specifications; 16,000 lbs. per sq. in. tension. All rods in trusses were given 3000 lbs. initial tension, and all stresses increased 25 per cent. for wind. The details in timber design call for more attention than in steel design since there is no handbook of standards for timber connections such as the Cambria and Carnegie handbooks for steel, and to reduce this work to a minimum the bureau issued a sheet showing the various standards to be used. During the design in timber framing it is also necessary to inspect the work with a view to using sizes of material which are most easily and economically obtained in the open market. This part of the work was largely handled on the advice of the bureau of estimates, which bureau prepared all lumber lists and specifications for lumber contracts.

Those familiar with construction work will readily realize the truth of the statement that in building construction when the contract cost of the work ranges from 200,000 to 400,000 dollars, the contractor must plan his work accurately and systematically and be ever on the outlook to see that all false motions are eliminated, if he is to realize the profit which he figured into the contract price.

A few false moves of the fundamental nature, such as over equipment of the work or improper planning of fabrication operations with the attendant result that the erection equipment is permitted to be idle, will soon eat up whatever profit there may originally have been in the contract price



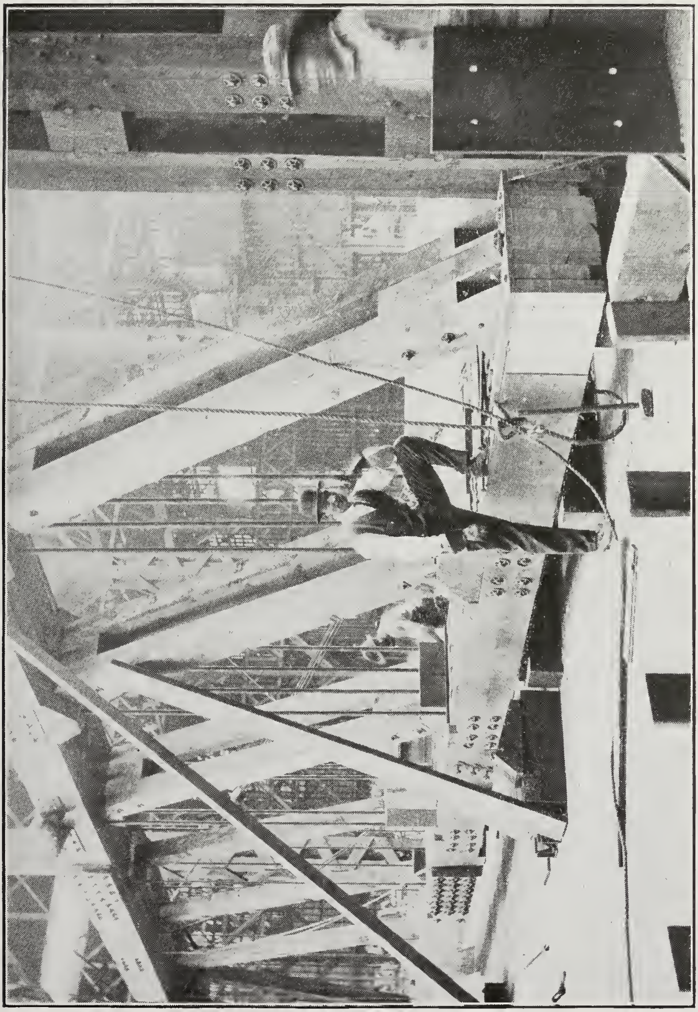
Typical Portion of Four Post Column Supporting Main Truss Under Dome of Palace of Education.

and the contractor who makes these errors may consider himself lucky if at the completion of his contract his books do not show an actual loss on the work.

No where has the writer seen a better opportunity for the comparison of construction methods than is to be had in the construction of the main group of eight buildings. Of these eight buildings, three are under contract with one firm, two with another firm, while each of the remaining three buildings is under contract with a separate firm. It is, therefore, possible to compare the work and methods of five different concerns, each doing the same type of work and working under similar conditions, as regards ground space available for plant and storage of materials, time limitations, transportation facilities, centers of population and the like.

In making comparison of methods used, the reader should recall that the Exposition Company furnished a certain amount of lumber required for the construction of any one building. This is the major portion of the lumber required, and a very carefully prepared detailed lumber list is furnished to the contractor to show him exactly what size and length of material was ordered to cover the lumber required for a given purpose. This was necessary on account of the fact that no two people in preparing a buying list would make the same combination of the various short pieces of lumber required in actual construction. It also should be remembered that due to the limited space available for purposes of storage of material, it was found necessary to insert a clause in the contract providing that a contractor should construct the floor of his building before beginning on other work. By doing this he was enabled to use the floor space for plaster shop, storage of material, etc.

We then have a condition admitting of very little initiative on the part of the contractor up to the time the floor is completed. As soon as work starts on the super-structure we find that there are two general plans of procedure being followed. First, there is the method of placing all material necessary for the various parts of the structure on the floor and fabricating the various columns and trusses in their approximate location, this fabrication being nearly completed before any erection is begun. The erection work is then begun and the construction superintendent gives his time entirely to this operation. Second, there is the method of placing materials on the floor for a small portion of the structure and concentrating the fabricating force on this one particular portion. While this work is going on, the erection equipment is assembled so that as soon as there is a day's work ahead for the erection crew, the work of erection is started, and from this point on the erection crew is not more than a day behind work of fabrication.

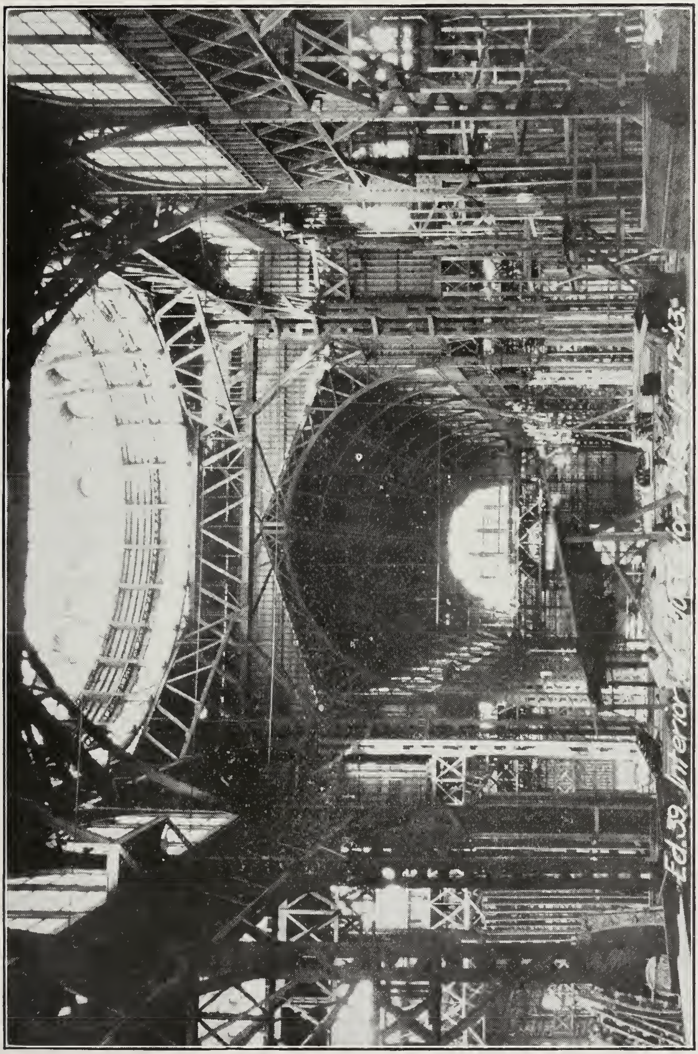


Main Truss "B" which carries one-fourth of the Total Load of the Main Dome of the Palace of Education.

Assuming that those in charge of the work have taken the necessary steps to insure reasonably prompt delivery of materials, the two general methods as above outlined each have their good points. The first method is to be recommended because of the following points: the maximum amount of time is obtained for study of erection methods and equipment to be used; the energies of the contractor and his superintendent may be concentrated on one operation at a time; the chances of delay in the work of the erection crew are reduced to a minimum; the maximum flexibility in fabrication operations is obtained; and the chances of accident to workmen during fabrication operations is reduced to a minimum since there is no danger of accidental injury due to material falling from above. The principal arguments against the first method are as follows: It is to the advantage of the contractor to get the material in place and receive the progress payment on the same; there is little chance of that very desirable rivalry between fabrication and erection crew which tends to expedite the work of each; the first law of the efficiency expert is violated in the fact that there is a lapse in the continuity of the process of construction. In other words, the parts first fabricated lie inert for a month or six weeks after being completed ready for the final operation of erections; and where time is of the essence of the contract, as is manifestly true in the work under consideration, it is quite probable that this method will require twice the outlay in erection equipment that would be required in the second method.

Let us now consider the arguments in favor of the second method: the minimum amount of capital is tied up since the maximum amount of material handled is subject to monthly progress payments; the outlay for erection equipment is reduced to a minimum; the work of fabrication is prosecuted to a maximum speed since delay in fabrication means loss of both time and money in erection. The principal arguments against the second method may be summed in that liability to accident from pieces of material falling from overhead is slightly increased, and delay in the prompt delivery of any one item of material is more liable to cause serious delay in erection and consequent loss of profit on the equipment.

As a rule, it is more reasonable to base one's decision on concrete results than on the intangible, and following this rule it would appear that the second general method should be followed. The foregoing is in the nature of a theoretical analysis of methods and in this connection it is interesting to note actual results as obtained on the construction of the eight main buildings above referred to. Of the five contracting firms doing this work, four followed



Typical Dome Framing Used in Main Group of Buildings.

the first method, and one the second method of procedure; or, in other words, six of the buildings are being built on the first method and two on the second method.

The contracts for the buildings were let in the following order:

1.	Palace of Education	March 17, 1913
2.	Palace of Food Products	April 9, 1913
3.	Palace of Agriculture	April 26, 1913
4.	Palace of Liberal Arts	May 20, 1913
5.	Palace of Manufactures	May 26, 1913
6.	Palace of Transportation	July 14, 1913
7.	Palace of Varied Industries	June 17, 1913
8.	Palace of Mines	July 15, 1913

The first six buildings in the above list are the ones which are being constructed according to the first method, while the last two are being constructed according to the second method. Of the first six buildings the fourth, fifth, and sixth as shown in the list are distinctly behind the last two, and some feel that it is more than possible that the last two buildings shown in the list will be completed before the second and third are completed. This condition is not entirely due to following the second general method of procedure on the last two buildings, but, in the opinion of the writer, a large measure of the rapidity and general success of this contracting firm is due to the general method which they selected.

In addition to the work of building construction the bureau of estimates also has to deal with the contracts for the construction of sewers, high pressure and low pressure water systems, paving, and electric wiring. The sewers are constructed principally of wood stave pipe for the large diameter and second quality vitrified tile pipe for the smaller sizes. Lap welded steel pipe with converse lock joints is used for the low pressure water system, while for the high pressure water system a heavy grade of lap welded steel pipe with dressed couplings and long radius extra heavy cast iron flanged fittings are used. The electric wiring is of the open knob and cleat type. The material and workmanship will comply with the 1913 edition of the National Electric Code.

In closing this paper it may be of interest to state the following distribution of funds for the construction work as outlined above:

General construction	$2,044,000.00
Mechanical features	492,000.00
Fire protection and equipment	166,000.00
Building construction	5,864,000.00
Decorative features	1,989,000.00
	$10,555,000.00

The remaining $945,000.00 not here accounted for but allotted in the budget for buildings and grounds, is set aside to cover the cost of gardens and planting, operating equipments, administrative expenses of the division of works, and miscellaneous items, such as drinking fountains, seats and benches around the grounds, furniture for the Exposition Company's building, floats for pyrotechnics, small boat landings, freight platforms, etc.

THE INSTALLATION OF A COST SYSTEM

H. E. Caldwell, '10

The rapid development of our industries during recent years, together with the complexity of their output, is making it necessary for the executive to know exactly what his plant is doing at all times. To meet competition he finds it necessary to know not only what each completed manufactured article costs, but he must know what each part and each operation costs. A comparative study of similar parts or operations often disclose "leaks," which can be eliminated and better manufacturing methods substituted. An analysis once a month or oftener, instead of once a year from the inventory, discloses the dull and busy periods, also the fluctuations in the market. He is thus enabled to redistribute his output more uniformly.

These, and many other conditions, have given rise to cost accounting. It has been rightly said that cost accounting begins where regular accounting ends, and it is largely an engineering problem. When it is applied to an industry with sufficient details, the cost system should give cost per unit for each product; give operation costs; give location and condition of each unfinished job; show amounts of productive labor and non-productive labor, and their distribution; show amounts of productive and non-productive material; show total output by operation; show average output per month; show ratio of expense to productive labor per department; compare operation costs to see if change methods result in net saving; compare total costs per month with sales; and give costs of all goods sold.

There are about as many systems as there are industries, so that no standard system can be given to cover all cases. It is the purpose of this article to give briefly some suggestions that might prove helpful in installing a system.

The first thing necessary is to find out exactly what costs the executive actually wants and needs to know. It is necessary to have his hearty coöperation, for his attitude will affect the rest of the organization, and without it the system would be about as useful as an idle machine in his plant. The abilities and habits of the rest of the organization should be known and utilized, as much as possible.

Habit often means efficiency, and it plays a large part in any industry. Men should be allowed to do the work for which they are best fitted. Caution should be used in creating new departments to satisfy an accounting system. Rather the system should be made to fit the existing conditions. This exact knowledge of the men and the conditions in a plant cannot be acquired easily by an outsider in a short time. Many of the failures of cost systems, after they have been installed, can be traced to this cause. This is why many companies are enlisting the services of their own engineers in the solution of this problem.

The frame work upon which the whole system is built is the chart of accounts. The more care that is taken in getting this as nearly exact as possible, before the work starts, the better the results will be. There should be a chart of general accounts, which may be subdivided as follows:

ASSETS

Cash accounts.
Inventory accounts.
Plant accounts.
    (a) Real estate and buildings.
    (b) Machines and tools.

LIABILITIES

Outside accounts.
    (a) Accounts payable.
    (b) Interest and discount.
Reserve accounts.
    (a) Depreciation on buildings.
    (b) Depreciation on machinery.
    (c) Interest on investment.
    (d) Taxes.
    (e) Repairs.
    (f) Inventory overs and shorts.
Capital accounts.
    (a) Investments.
    (b) Profit and loss.

An operation chart of accounts is also necessary. The plant should be divided into its productive and non-productive centers or departments. Under each department may be listed the operations performed in that department, and as nearly in the order in which they are performed as possible. Care should be used in showing only those operations whose costs it is necessary to know. Otherwise, the office is easily swamped with useless details. Later each department can be subdivided as much as is deemed necessary.

Each department and each operation may contain the following accounts: Labor, fuel, fixed charges, sundries, supplies, and power. Each account in the chart should have an individual number, and this number should be used instead of the name of the account, as it will save a great deal of clerical labor. An example of this kind of a chart is as follows:

STEAM PLANT

Acct. No.	140	Labor
	141	Fuel
	142	Fixed charges
	143	Sundries

SHEET METAL DEPARTMENT

144	Labor
145	Fixed charges
146	Sundries

BLANKING

147	Labor
148	Power
149	Fixed charges
150	Sundries

One of the most important items affecting the true costs, is the proper interpretation and distribution of the values of the buildings and equipment in the plant. These values are placed in the fixed charge accounts. A very good method of obtaining and recording these fixed charges is by the use of the fixed charge sheet. This sheet should show the names, values and rates of depreciation of the various items charged to each operation, and it is very convenient in the handling of future changes of operations or equipment.

Before obtaining the values of the equipment, a plat of the plant should be obtained and the various buildings should be designated by some symbol; i. e., Building A, Building B. Then drawings of the floor area of the different buildings should be obtained. These drawings should show the location of the machines, motors, line shafts, and such other equipment as seems advisable. The machines should all be numbered for purposes of identification and repair record. A very successful method of numbering the machines is to let the first symbol be that of the building, the second the number of the floor, and the third of the machine. Thus, A-2-17 shows that it is machine No. 17 on the second floor of building A. The floor space should be divided into sections; the productive space being charged directly to the various operations, and the non-productive space being charged to the general fixed charge account for the department in which it is located.

In obtaining the physical value of the plant, it is convenient to obtain, where possible, the original value of the various items from appraisals, office records, or unit cost data, and then obtain a certain per cent. of the original value for the present value. The "present value" does not necessarily mean the price for which the owners would be willing to sell the equipment, nor the price that could be obtained by selling to others, nor the cost to produce, but it should represent the value of the equipment to the owners in continuing the manufacturing processes as they now exist. Any change in methods or equipment which can be foreseen, can be taken care of by a greater rate of depreciation.

To avoid confusion, repetition or omission of fixed charge items, it is advisable to group them into separate classes, and to collect the costs of each group separately. Items should be charged directly to operations where possible. If they are common to more than one operation, their value should be prorated. The following shows the method of classifying and obtaining values for the fixed charge sheet:

MACHINES—Includes initial cost, cost of installation, driving belts and countershaft. Charge directly to operation.

FURNACES—Includes initial costs, installation and initial bricking. Charge directly to operation.

BLOWERS—Cost installed. Charge directly or prorate by number of burners.

PIPING AIR AND OIL—Cost installed including mains, branches, storage tanks, stand pipes, and pumps. Prorate by the number of burners.

TRANSMISSION—Cost installed of line shafts, pulleys, driving belts, and motors. Prorate by H. P. of machines driven.

EXHAUST SYSTEMS—Cost installed. Prorate by number and size of outlets.

BENCHES, RACKS AND TABLES—Charge directly to operation or department.

DIES, FORMS, AND SPECIAL TOOLS—Charge directly to operation or department.

TRANSPORTATION—This includes elevators, conveyors, chutes, derricks, trucks, monorails, etc. These should be charged directly to operations where possible, or prorated by floor area to the departments to where they apply.

BUILDINGS—These should be prorated to departments and operations by multiplying the square feet of floor space occupied by each, by the value of the building per square foot.

ILLUMINATION—This includes wiring, lamps, reflectors, and switchboards installed and may be prorated by the watts per sq. ft. of area lighted.

FIRE PROTECTION APPLIANCES—This includes sprinkler systems, trucks, hose, fire engines, pumps and hand extinguishers. These may be prorated by the square feet of floor area protected.

PLUMBING—This includes sewers, water mains, fixtures, etc., and may be prorated by floor area.

GENERAL EQUIPMENT—Items which apply to the whole plant such as office furniture, sheds, pavements, fences, etc., may be charged to a general fixed charge account.

For any given period, the fixed charges of any operation, which did not contain any productive labor, may be added to the fixed charges of its department. The general fixed charges of the departments, and the general fixed charges for the plant may be prorated to the various operations by the amount of the productive labor obtained from the pay roll for that period.

After assigning values to all of the equipment, the next step is to determine the life of each item, or its rate of depreciation. This is the basis on which the replacement fund is established. If the pay roll comes bi-monthly, then each machine or building is depreciated one twenty-fourth of its annual depreciation. This amount is shown on fixed charge sheets opposite each item of equipment. The rates of depreciation should be governed by the existing conditions in the plant, and by good engineering practice. The following rates may be used as a guide:

Machine shop machinery	3–5%	Exhaust systems	20%
Power hammers	10	Sprinklers	4
Tumblers	10	Horses	15
Saws	10	Office furniture	7
Power transmission	7	Benches	5
Electric wiring	10	Fire protection piping	10
Hoists	5	Steam piping	10
Furnaces	8	Water piping	7
Dies	35	Sewer piping	3
Patterns	7	Gas and air piping	4
Trucks	10	Heating system	10
		Buildings	2–10

The interest per year on the investment is prorated by the total value of buildings and equipment for each operation or department. Taxes and insurance may be prorated by the floor area of each operation or department.

In the operation of a cost system, a large number and variety of forms are necessary to keep the various records, and the printing bill is a large item. It is advisable to utilize, as much as possible, the forms already in use, and the size of the new forms should be some multiple of the standard printers' sheets, to avoid waste in cutting. These items are often neglected by cost accountant experts.

The subject has not been fully covered in this article. The method of handling labor accounts, orders, raw material and supplies, and all the other accounts that go to make up the monthly analysis sheet has not been touched. Those items which have been mentioned are ones that must be met by the man on the job, and it is hoped that the suggestions offered may be of some assistance in the solution of similar problems.

A HYDRO-ELECTRIC INSTALLATION IN CENTRAL HONDURAS

V. T. Mavity, '13

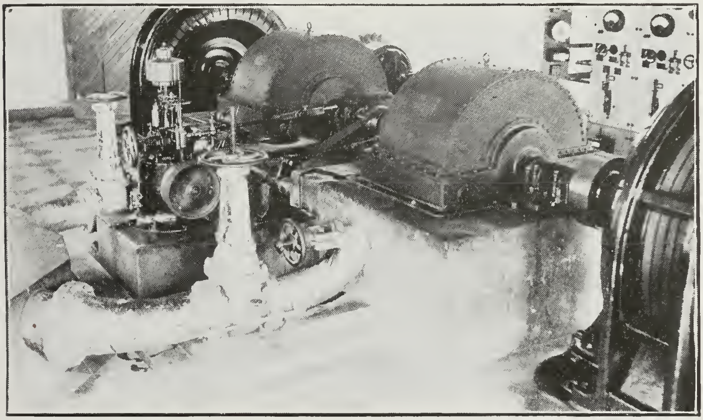
All of the energy that is used in the Rosario Mines, which are located near San Juancito, Honduras, Central America, is supplied by two hydro-electric power stations, one of which is at San Juancito, and the other at Guadalupe, about one and one-half miles north and east of San Juancito. Mountain streams furnish the water supply for both plants. More than a quarter of a mile above the level of San Juancito there are dams across the streams from which the water is carried in wooden canals to the San Juancito water box. The water that is not directed into the canals flows on down to San Juancito, where the two main streams meet and flow past the power station. Just below the station, there is a dam, which directs the water into the Guadalupe canal. The discharge water from the San Juancito plant also flows into the Guadalupe canal and is used again at Guadalupe.

The Escobales flume, from the farthest dam to the water box, is two miles long with a grade of 0.66 per cent. and is two feet wide and 18 inches high. The San Juancito canal is 2½ feet wide by 18 in. high, is 7300 feet long and has a grade of 0.50 per cent. Through these two canals the water flows to a water box of wood construction which acts as a small reservoir at the head of the pipe line. The Guadalupe flume is three ft. wide by two ft. high and 6000 ft. long. Its grade is 0.20 per cent.

The San Juancito pipe line is made up of three different sizes of pipe. The first is 20 inch riveted pipe, and runs from an elevation at the water box of 1345 feet above the power plant, down to an elevation of 1054 feet, making a total length of 784 feet. At this point, there is a section of tapered pipe which changes from 20 to 17 inches. There are 708 feet of 17 inch pipe which runs down to an elevation of 788 feet. From this point on down to an elevation of 644 feet, there is 689 feet of 14 inch riveted pipe, and from the 644 foot elevation to zero elevation, at the power plant, there are 2347 feet of 14 inch lap welded pipe. This makes a total of 4528 feet of pipe line and a total head of

1355 feet when the water box is full. Where the pipe line enters the power house, it divides into two branches, one for each machine. There are three valves on each of these branches—first, the main valve; second, the by-pass valve; and third, the needle valve which controls the size of the jet that issues from the nozzle.

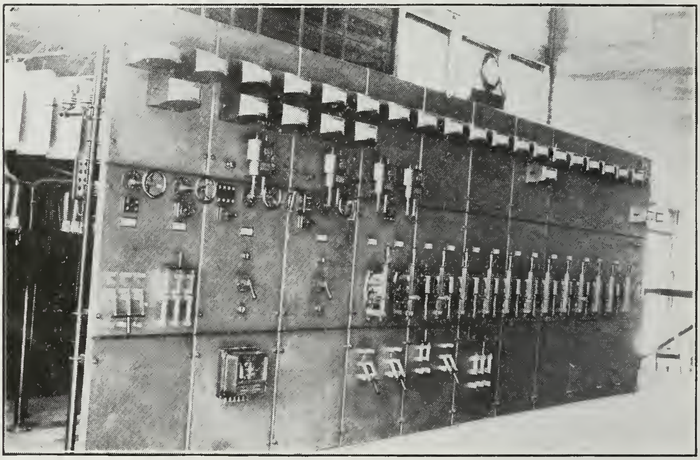
The pipe line for Guadalupe is all 20 inch riveted pipe and is 2500 feet long. When the Guadalupe water box is full, the static head at the plant is 486 feet. The pipe and valve arrangement inside the plant is the same as at San Juancito.



Pelton Water Wheels in Guadalupe Plant.

At the San Juancito plant, the equipment consists of two Pelton impulse water wheels, direct connected to Westinghouse 350 kv.a., three phase, sixty cycle, and 6600 volt alternators. The machines run at a speed of 600 r.p.m., which is controlled by means of a Pelton hydraulic governor. The principle of this governor is the deflecting of the water from the wheel whenever the speed tends to exceed the normal. This deflection is accomplished by means of an iron hood which swings in front of the nozzle and cuts off part of the water. A piston which is operated by oil under pressure, controls the movements of this hood. Whenever the speed tends to drop, the oil pressure causes the piston to move in such a manner that the hood will deflect less water. If the speed tends to increase the oil is forced into the other end of the cylinder and the piston moves the hood so that it will deflect more water. The oil is directed to the proper end of the cylinder by means of a distributing valve which is actuated by a centrifugal device. At the same time that the distributing valve admits oil to one end of the cylinder, it opens a port to let out the oil in the other end. A gear pump which maintains the oil pressure together with the centrifugal device, is driven by a belt from the Pelton shaft.

Since the deflecting hoods of each machine are mechanically connected so that they act together, the one governor serves for both machines. When the governor is for any reason out of service, the deflecting hoods are controlled by a hand wheel.



Switchboard in Rosario Substation.

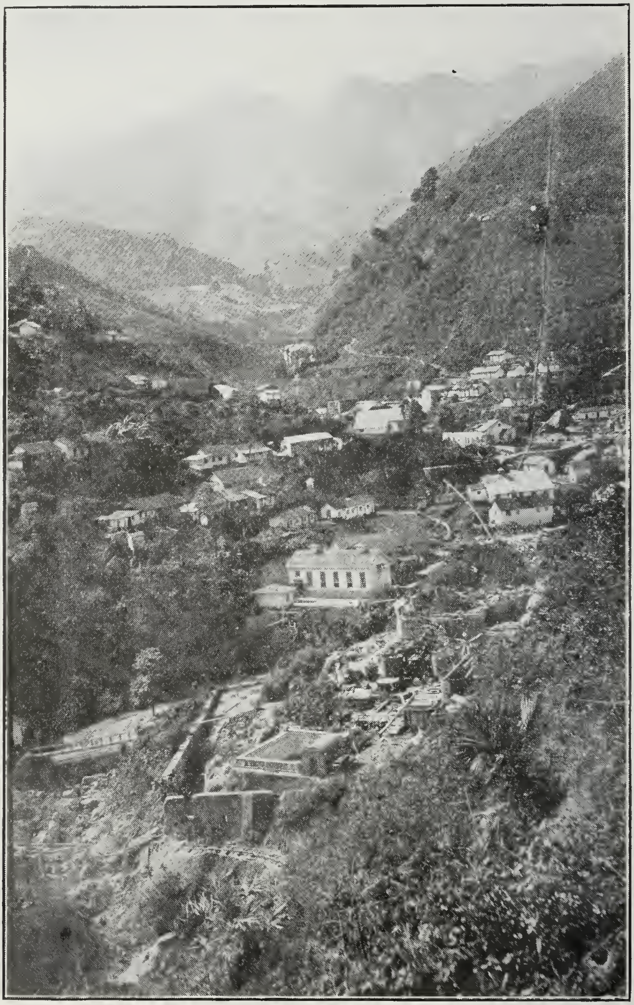
There are four panels on the switchboard—one exciter panel; two panels for the two alternators; and another panel with a power factor meter, an ammeter that reads total current for the station, and an automatic oil switch for the protection of the station apparatus. Besides these main panels, there is a small voltage regulator panel at one end, and a swinging bracket with voltmeter and synchroscope at the other end of the switchboard. At Guadalupe, the equipment is practically the same, except that the apparatus is General Electric instead of Westinghouse, and that there is no automatic oil switch panel on the switchboard. Each plant is protected from lightning and heavy surges by an aluminum cell lightning arrester used in connection with choke coils.

The two plants are operated in parallel. At the junction of the transmission lines there is a switch house with switches so arranged that either section of line may be cut out of service for repairs without interrupting the operation of the other plant. Either voltage regulator may be used alone, but the two regulators will not operate together because the line drop between each plant and the switch house is different except at a certain definite load for each plant. Consequently, except at this definite load, each regulator tends to give a different voltage at the switch house and they therefore work against each other. This difficulty could be remedied by adding a line drop compensating coil to each regulator. However, for the service here, one regulator is always sufficient to control the voltage, and for that reason the compensation for line drop has never been made.

Perhaps the greatest source of trouble in the operation of these plants is due to the interruption of the water supply to the pipe line. In the majority of cases, the reason for the water being held back, is that dirt, grass, leaves, etc., accumulate on the screens inside the water box at the entrance to the pipe line, thus effectually holding back the water so that instead of going through the screens, it overflows at the spillway. When the water is held back from the Guadalupe pipe line, it is only a matter of a very few minutes until the pipe line runs half dry, thus throwing the whole load suddenly on the other plant. In case of trouble at the San Juancito water box, however, the pipe is so long that almost the whole load may be carried for several minutes, thus giving plenty of time to notify the other plant and to call one of the sub-stations and have the load cut down until the water pressure returns to normal. At Guadalupe there is an automatic low pressure alarm which, when the pressure drops to the critical point, rings a bell that notifies the operator of the low pressure.

There are two sub-stations in the system. One is at Rosario, in the "Mill" building, and the other is in the air compressor station at Pena Blanca. At Rosario, the voltage is stepped down from 6600 to 2200. The stamps, which crush the ore, are driven by a Westinghouse 150 H. P. synchronous motor, with an additional 110 H. P. synchronous motor for emergency use. There is one clutch on the main shaft between the two motor pulleys and another clutch between both motor pulleys and the load. An induction motor, belted to the same section of main shaft as the emergency motor, is used for starting either motor.

The induction motor, however, drives both motors above synchronous speed. A special synchronizing device for starting the motors is employed, the following steps being required for starting: first, start the induction motor; then put field on the synchronous motor and raise its voltage to a predetermined value above line potential. It must be re-



San Juancito Plant. Pipe Line Shown in Background.

membered that the induction motor drives the synchronous motor above synchronous speed, and, if its voltage is above normal when the speed is above synchronism, then when the speed drops to synchronism, the voltage will at the same time drop to line potential. Having the synchronous motor running above synchronism and the voltage above normal, the induction motor oil switch is tripped out and the speed and voltage begin to drop. As soon as the induction motor circuit is opened, the control switch of the automatic synchronizer must be moved to the closing position, and when the speed and voltage of the synchronous motor decrease, so that they both reach normal at the same time, the automatic synchronizer closes a direct current circuit which closes the main switch. The synchronous motor is operated with a leading power factor of .60. This is done to raise the low lagging power factor of the line caused by the induction motor load.

At the Pena Blanca sub-station, the voltage is stepped down from 6600 to 440. The air compressors are driven by two 440 volt, 280 H. P. induction motors. There is also a motor generator set that supplies 250 volts, d. c., to operate the electric locomotives at the Pena Blanca level. There are in the mill, in the shops at Rosario and at Pena Blanca, and in the compressor station, 55 motors aggregating about 1600 H. P. In addition to these motors, there are six electric locomotives which haul the ore trains from the mine to the mill. Both sub-stations have aluminum cell lightning arresters, used in connection with choke coils, to protect the apparatus from lightning and heavy surges on the line.

Although the transmission line runs from an elevation of 3179 feet, at Guadalupe, to a 5895 foot elevation, at Pena Blanca, yet the line is entirely free from any noticeable atmospheric disturbances. However, in order to minimize such trouble, should it ever arise, there is a ground wire running on top of each pole from Guadalupe and San Juancito to the end of the line at Pena Blanca.

STREET LIGHTING IN CHICAGO

A. B. Gates, '09

During the year 1887, 105 direct current open arc lamps were installed in the down town district of Chicago. From year to year, lamps of the same type were added, until in 1898 there were 1,710 lamps operating. Up to this time, the lighting had been operated by a separate bureau of the fire department, but in 1898 the electrical department was created. The direct current arc lamps were supplied with current from Brush arc machines, belt connected to steam engines. An alternating current plant was added, and by 1908 there were 8,600 arc lamps operating on the streets of Chicago.

In the year 1908, the City of Chicago entered into a contract with the Sanitary District of Chicago, whereby the Sanitary District of Chicago was to supply the city with power. This contract made possible the much needed extensions in the lighting system. The steam engines were disconnected in the direct current stations and synchronous motors installed to drive the Brush arc machines. Transformers were installed in the alternating current stations and the steam engines and generators in these stations held for reserve capacity. Other alternating current stations were added and the lighting capacity was greatly enlarged. In 1910, there were 12,000 arc lamps in operation and during that year the City of Chicago entered into a second contract with the Sanitary District of Chicago, by which the Sanitary District agreed to operate and maintain the city lighting stations and to install 10,000 alternating current arc lamps of modern type, or their equivalent in other forms of lighting; also, to build the necessary stations (at least three in number), to take care of the new lighting, and to rehabilitate the old lighting system; and to replace the old direct current arc lamps and station equipment with modern alternating current arc lamps and station equipment. When this contract is completed, there will be on the streets of Chicago over 25,500 arc lamps or their equivalent. Over 75 per cent. of these will be lamps of modern type.

The arc lamp adopted, and of which there are about 10,000 now installed and operating on the streets of Chicago, is the "series alternating current long burning 10 ampere, flame arc lamp." These lamps are trimmed with white flaming carbons and adjusted to 465 watts at the terminals so as to have a maximum intensity of about 1,700 candle power at an angle of 25 degrees with the horizontal. They are being installed in the business and manufacturing districts, and in the residential districts where there are few trees. In most cases, the arc lamps are hung on one side of the street about 25 feet above the ground and average about 23 lamps to the mile. The same type of lamp is in general use on the boulevards, but here they are on both sides of the streets, staggered, and more closely spaced than on the business streets.

From 65 to 70 of these lamps are connected in series and from 30 to 60 circuits are operated out of one station. In most of the business districts, underground type of construction is being used. The cable is carried up through the iron pole and out through the hanger arm, all connections thus being concealed. In the outlying districts, aerial construction is used. In all the new districts, the lamps are provided with a raising and lowering device with an automatic circuit cut-out, so that the lamp may be lowered for inspection without disturbing the rest of the circuit and without danger to the repairman.

In the residential districts, where the trees would interfere with arc lamps which are necessarily hung a considerable distance above the street, four ampere 80 candle power, series, tungsten lamps are being installed. The lamps are mounted in a 14 inch spherical, opalescent globe about 11 feet from the ground, on a hollow cast iron pole. The pole is set in the parking about two feet from the curb. Iron armored cable is used for connecting these lamps. This cable is laid in the parking just inside the curb and buried about 1½ to 2 feet in the ground. The cable is run up through the hollow pole, so that all connections are concealed. These lamps are placed on both sides of the street and staggered so that there is a lamp to every 75 feet of street. About 230 lamps are connected in a circuit. There will be about 7,000 of these lamps installed.

An attempt has been made to divide the city into suitable districts so as to operate as many circuits as possible from one station, and in this way cut down the cost of operation. The power is distributed to these stations at 12,000 volts and is stepped down to 5,000 by 250 kv.a. transformers which are connected delta on the 12,000 volt side and star on the 5,000 volt side. The neutral of the low tension side is grounded and all banks in the station are normally operated in parallel. The arc and incandescent circuits are taken off of the live buses through automatic oil switches and induction type, constant current regulators, to the circuits, then back from the circuits, through air break disconnecting switches, to the neutral bus. This system is used in all the arc lighting stations in Chicago.

In districts where there is no electric lighting, a new type of single inverted mantle gas lamp is used. The lamps are about 12 feet above the ground and develop 50 candle power with a gas consumption of three cubic feet per hour. Gasoline mantle lamps were installed in such districts as were not supplied with gas mains. These lamps are very much like the gas lamps in appearance, except that the mantle is not of the inverted type. They develop 50 candle power through all glassware.

Besides the regular street lighting furnished by the city, there is a type of multiple cluster tungsten lighting supplied and maintained by the Chicago Edison Company and paid for by the merchants along the street. These clusters are placed a little inside the curb in accordance with a recent ordinance, which in the down-town district requires five lamps—one at the top of a 14 foot pole with the remaining four a little below, symmetrically arranged about it. In the outlying districts 12 foot poles are used. This lighting is turned off between 11 o'clock and midnight.

The elevation of the steam roads gave rise to a troublesome problem in the lighting of the subways or viaducts under these tracks. Some of these viaducts are nearly a half mile in length and must be lighted continuously. A standard of one 16 candle power lamp to every 400 square feet of street and sidewalk was adopted. Lamps are placed in the center of the ceiling above the sidewalk, with 20 foot spacing. The remaining lamps are then divided and spaced evenly along the curbs. In the first installations, the lamps were placed in enameled reflectors with the reflector throwing the lighting perpendicularly across the street, but it was found that by turning the reflector so as to throw the light across the street at an angle of 45 degrees with the direction of travel, a much better effect was obtained. By this scheme, the traffic ahead of the vehicle is illuminated and the reflector keeps the glare of the lamp out of the driver's eyes, as there is no light thrown opposite to the direction of travel, except that from the other driveway, and this causes little trouble, since the streets are comparatively wide and the center supports tend to cut off this light.

At the present time there are installed in the streets of Chicago,

10,000	10 ampere, alternating current, series, flame arc lamps,
1,300	9 ampere, direct current, open arc lamps,
4,700	6.6 ampere, alternating current, enclosed arc lamps,
3,500	4 ampere, alternating current, series, tungsten lamps,
12,000	inverted mantle, 50 candle power gas lamps,
6,500	upright mantle, 50 candle power gasoline lamps.

When the work covered by the present contract between the City of Chicago and the Sanitary District of Chicago is completed, there will be in operation in the streets and boulevards of Chicago over 50,000 lighting units.

The following approximate figures will give a fair idea of what it costs to operate and maintain the various types of lighting. These figures include interest and depreciation:

	Cost of lamp per year
10 ampere, flame, aerial type of construction	$55.00
10 ampere, flame, underground type of construction	73.00
4 ampere, series tungsten, underground type of construction	26.00
Gasoline, single mantle	30.00
Gas, single, inverted mantle	22.00

The cost per mile of lighting per year, including investment charges, is approximately as follows:

Flame lamps, underground type of construction	$1,700,00
Flame lamps, aerial type of construction	1,300.00
Series tungsten lamps	2,000.00
Inverted mantle single burner gas lamps	1,700.00

HYDROGRAPHIC AND TOPOGRAPHIC SURVEY OF THE WABASH RIVER AND VALLEY

E. B. Newell, '11

By Act of Congress in 1910, an investigation of the feasibility of improvement of the Wabash river from its mouth to Terre Haute, Indiana, was authorized. The investigation covered the possible methods of canalization, regularization, dredging, reservoirs, and combinations of these operations.

To secure the necessary data, a survey of the river and its valley subject to overflow at extreme high water was made under the direction of the U. S. District Engineer Office at Louisville, Ky., by Geo. H. Wolbrecht, U. S. Assistant Engineer. Preparations were started for the survey in the spring of 1911. The construction of the necessary equipment and requisition for instruments from Washington, D. C., covered a period of several months. In June, 1911, while these preparations were being made, a party was sent out to establish permanent gages at the following places: Terre Haute, Ind.; Darwin, Ill.; Riverton, Ind.; Vincennes, Ind.; St. Francisville, Ill.; Grayville, Ill., and Maunie, Ill. Permanent gages already existed at Grand Rapids Lock and Mt. Carmel, Ill. These gages were, in most cases, placed on bridge piers with a view to permanence. Observers who, in most cases were bridge watchmen, were appointed to keep a daily record of the stage. Elevation of the zero of these gages was referred to bench marks, the elevation of which was later determined by the precise level party.

The work of preparation was completed and the survey was organized at Terre Haute, Ind., in July, 1911. The floating plant necessary to carry on the survey consisted of two small house boats purchased and remodeled for the purpose of a survey party; one large quarter boat built for the purpose; one barge to carry provisions and property; one barge used as a drill boat; three especially designed gasoline launches; and six 24 foot yawls. The entire plant was designed to meet the conditions demanding strength and light draft.

In order to secure accurate results, it was decided to run a carefully measured base line and a line of precise levels, with separate bench marks for each, as a control for the survey. To make the river survey during the favorable low water season, it was decided to run the control and make the river survey on the first trip down the river, and then return and make the valley survey on the second trip. The control was run ahead of the topographic and hydrographis parties, so that computation necessary for the elevation and position of the permanent marks could be made.

The precise level and base line parties were organized as a unit and used the two smaller quarterboats; a supply boat; one gasoline launch; and three yawls as their floating plant. This party took the field July 20, 1911. Their organization at first consisted of one base line party and two precise level parties, but when it was found that the two precise level parties covered distance more rapidly than the base line party, one level party was converted into a low water discharge party and finally abandoned altogether. This party completed its work on the tenth of December, 1911, and was converted into a topographic and hydrographic party which assisted the second party to complete the river survey.

The base line consisted of a traverse, carefully taped with a standardized steel tape by two independent parties. The results were corrected for temperature and the two results had to check within the limit of one in 20,000 or the line was retaped. The courses were read by stadia as a check for large mistakes. The angles were read six times with a 10 in. transit-theodolite and the corrected azimuth was obtained by observation on Polaris and 51 Cephei at intervals of about 10 miles. Permanent bench marks were set at intervals of about every mile.

The latitude and longitude of the U. S. Coast and Geodetic Survey astronomical station at Vincennes was used as the basis of all horizontal measurements of the survey. A duplicate line of precise levels was run the entire length of the survey under the published instructions of the Mississippi River Commission with Kern levels borrowed from that office. Permanent bench marks were established at intervals of about five miles. Special care was taken in the setting of these marks in order to insure permanence and recovery. All elevations of the survey were finally referred to the 1907 adjusted value of the U. S. Coast and Geodetic

Survey bench mark Az at Vincennes, Ind., which is referred to mean sea level at Sandy Hook, N. J. References were made with the permanent marks of the U. S. Geological Survey at Terre Haute, Ind.; Shawneetown, Ill.; and also to permanent marks of the Ohio River Survey near the mouth of the Wabash river.

The topography was taken by transit and stadia in accordance with the published instructions of the Mississippi River Commission—the contour interval being five feet. All topography was plotted and sketched in the field as an aid to the final plotting. On the river survey, all features included between the low water line and main high banks or levees in close proximity of the river were taken. Special care was taken to locate caving banks and the extent of the bank in each case where cutting was in progress.

Probings consisted of driving a 25 foot rod to a depth of 20 feet below low water elevation to determine the character of the material of the river bed. Probings were taken at designated possible lock sites and on bars where there was less than four feet of water at low water stage. Three holes were driven on a range, one near each bank and one in the channel. Probings were taken on ranges about 450 feet apart, that is, alternately on the sounding range and midway between the next two sounding ranges. The exact location of the holes was not considered essential. The ordinary level party established elevations on water surface pegs, stadia stakes, base line bench marks, high water marks, and bottom chords of bridges.

Discharge measurements were taken with a Price current meter set at 0.6 depth where mean velocity was assumed. Low water measurements were taken at Terre Haute, Ind.; Vincennes, Ind.; Mt. Carmel, Ill.; New Harmony Ind., and below the mouth of Little Wabash river. Later, complete discharge curves were desired at Vincennes, Ind.; Mt. Carmel, Ill., and below the mouth of Litte Wabash river. These measurements were taken as the required stages became availabe. The current meter was rated in a pond near Vincennes and in the lock chamber at Grand Rapids lock and dam.

Considerable trouble was experienced in the moving of boats during the low water season, particularly on the river survey. The channel was so narrow, shallow, or tortuous that it was impossible to move the boats without much difficulty and loss of time. Although the maximum draft was only 15 inches, the boats were many times riding snags or grounded on bars. Many devices were resorted to. The capstain on the large boat proved useful, while Spanish windlasses were often necessary on the other boats. The gasoline launches were of no avail as their power was sufficient to steer only in the current, and make landings. In one extraordinary case, six yawls were sunk and filled with sand to form a dike. By this expedient, the boats were moved after having been hard aground for 20 hours. The problem of getting provisions from the nearest market when the boats were away from town proved troublesome. Only one week's supply could be kept in store during extremely warm weather. Boats in several cases were 30 miles from a market. Hauling overland was out of the question because of distance and expense. The gasoline launches were too slow to make the trip, and very few boats on the river could be induced to run during the low water season. Provisions were obtained by chartering privately owned gasoline boats, but not without much difficulty and cost.

The river survey was completed by the first of January, 1912, and the entire fleet was then towed back up the river. Owing to the freezing of the river while enroute, the fleet was forced into winter quarters at New Harmony, Ind. The winter proved very severe and the fleet was badly damaged by ice. While the boats were in winter quarters, four topographic parties were organized and work on the valley survey was begun in the vicinity of New Harmony. The boats were used as a base for a brief time but as the work became too far distant for the parties to return at night, they were subsisted by farm houses, or hotels in small towns in the vicinity of their work.

About 200 square miles of the valley immediately above and below New Harmony on both sides of the river were covered during two months of very rigorous winter weather, marked by heavy snows, and temperature much below zero. On March 11, 1912, the fleet was again started up the river and reached Terre Haute on March 21. High water at this period forced a discontinuance of field work for about three weeks. After this time, the work was resumed and the valley was surveyed on the second trip down the river. Wherever practicable, the work was laid out in one-half mile lines normal to the general direction of the stream. Each party was assigned one or more of these lines according to their lengths.

The large acreage of corn in the lower Wabash valley was a source of much trouble, delay and expense, and it was found almost impossible to cover the country thoroughly. The valley survey was completed on the tenth of September, 1912, after about 775 square miles had been traversed. The work was accomplished in 587 days, thus averaging 1.32 square miles per party working day. The gross cost, including all over head charges, was about 25 dollars per square mile.

Computations, consisting of the preliminary and the final computation of the base line and precise level line, together with the geographic position and elevation of all bench marks and topographic stakes, ratings, and results of discharge measurements were made in the field. Reduction of notes was begun and partly finished in the field and later completed in the district office. Final plotting of maps and profiles was done in the district office.

After the completion of the survey, a flood, surpassing all preceding floods in height and volume, occurred in April, 1913. A party was dispatched to determine its height shortly after the water receded. An accurate determination of its height was obtained about every five miles to determine the high water profile.

The Purdue Engineering Review

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Field Broadens.

This number of *The Purdue Engineering Review* marks the first representation of the Chemical Engineering Society on the staff of the publication. All four engineering societies of the University now have an equal interest in this work. Though the School of Chemical Engineering is a comparatively new one, its growth has been rapid, so that it has quite a number of alumni engaged in fields of work which the *Engineering Review* has been unable to touch upon up until the present time.

Course in Seminar.

It is generally recognized that the majority of technical school graduates are unable to express their views and opinions before an audience in an intelligible manner. It has been said jokingly that the graduate of the liberal arts school can express himself freely and fluently but he has nothing to say, while the engineer graduate has plenty to say but he is unable to talk. This is a queer state of affairs, but nevertheless it bears a semblance of the truth. To meet this situation, the School of Mechanical Engineering administers the subject seminar for the first semester of the senior year. Every student in this school is obliged to take the subject which is conducted in such a manner that he gains an extremely practical training in speaking before a critical audience. For the most part the subjects chosen, usually by the speaker himself, are of technical nature. Criticisms are given freely and it takes but a few appearances before a noticeable improvement is made. In the course of Gas Engines, the second semester's work devolves into a lecture course which is so outlined that every student taking the subject shall give an hour's talk on some phase of gas engine work, which shall require considerable amount of reading for preparation. Too much emphasis can not be laid upon such courses, for the engineer who is unable to express himself clearly and exactly will find himself at a great disadvantage in the business world. Great ideas that cannot be expressed in words are of no value. The sooner that the young engineer learns to take advantage of every opportunity to explain his technical knowledge in an intelligible manner, the quicker will he advance.

INTERNATIONAL ENGINEERING CONGRESS.

The committee in charge of the International Engineering Congress to be held in San Francisco during the Exposition announces that rapid progress is being made in working out the final program of papers. The first volume of the publication of the Congress will consist of a series of articles descriptive of the various technical features of the design and construction of the Panama canal. Colonel Goethals will handle one of the 22 topics as well as the introduction. This volume will constitute practically an official technical record of the gigantic feat which is just nearing completion and will be of interest not only to engineers but to laymen.

It has been announced that Colonel Goethals will preside as chairman of this Congress of engineers who will gather from all over the world.

NEW BULLETIN ON USE OF ELECTRIC FURNACE IN MAKING IRON AND STEEL

The investigations that the Bureau of Mines is making into the metallurgical industries, the appliance of electricity to various processes, and especially in the manufacture of iron and steel, is given attention in Bulletin 67, "Electric Furnaces for Making Iron and Steel," just issued by the Bureau. The investigations into electric furnaces for making iron were made by Dorsey A. Lyon, and electric furnaces for making steel by Robert M. Keeney. The bulletin gives a historical review of the development of electric furnaces for making iron and steel, and discusses the problems which remain to be solved in the use of electric furnaces for the smelting of iron ores and the production of pig iron at a profit on a commercial scale.

"Broadly speaking," Mr. Lyon declared, "it may be stated that the feasibility of smelting iron ores in an electric furnace depends upon the relative cost of either charcoal or coke and of electric power. In those electric-furnace iron plants that are operating at the present time only hydro-electric power is used. In general, there are few localities where the electric smelting of iron ores would be feasible with the electrical energy costing more than $0.20 to $0.30 per kilowatt-hour."

Mr. Keeney states that, "The cost of making steel in the electric furnace varies with local conditions. The cost of power does not enter so largely into the final cost as it does in some other electrometallurgical processes, especially the refining of molten steel. Plants are operating successfully under a power cost of one cent per kilowatt hour in localities where material can be obtained at the price common to other processes. Plants such as the one at Ugine, France, have been established in remote localities, where the cost of power is very low, 0.2 cent per kilowatt-hour, but the cost of material is high.

"For many years all high grade steels were manufactured by the crucible process, but since the advent of the electric furnace there has been a gradual adoption of that furnace for refining steel. For the complete refining of the highest grades of steel the use of the electric furnace is now thoroughly established in Europe. Any product that can be made by the crucible process can be made by the electric furnace, and in most cases with cheaper raw materials and at a lower cost. In the electric furnace complex alloy steels can be made with precision. The high temperatures attainable facilitate the reactions and alloys need not be used so largely for the purpose of removing gas. Very low carbon steels can be kept fluid at the high temperatures. Steels free from impurities and of great value for electrical apparatus can be made. With the electric furnace large castings can be made from one furnace, whereas in the crucible process steel from several crucibles must be used. For small castings, which require a very high grade metal free from slags and oxides, electrically refined steel is especially adapted. The electric furnace gives a metal of low or high carbon content as desired, hot enough to pour into thin molds and still free from slags and gases.

"There is now a tendency among consumers of rail and structural steel to require a higher grade steel at an increased price rather than steel of acid Bessemer or even of basic open hearth grade at a lower price. With the high cost of power that now prevails throughout the steel centers of the United States the electric furnace can not compete profitably with either the acid Bessemer or the basic open hearth process in manufacturing steel of like grade from pig iron. It is in combination with either of these processes that the electric furnace seems destined to be prominent in steel manufacture. The cost of superrefining in the electric furnace the molten steel from either of these processes, exclusive of the cost of the molten steel, varies from $1.50 to $2.25 per ton, depending on the cost of power and the impurities to be removed."

Department Notes

SCHOOL OF MECHANICAL ENGINEERING.

CHANGES IN INSTRUCTIONAL STAFF

During the last year a number of changes were made in the personnel of the instructional corps in the Mechanical Engineering department. J. S. Staudt, Assistant Professor in machine design, resigned to take up work with a consulting engineer. Mr. T. T. Eyre has been away on a leave of absence and at the present time is head of the Mechanic, Hydraulic, and Testing Material Laboratory of the Case School of Applied Science. Mr. R. W. Noland has been transferred from the Engine Laboratory to Machine Design. Mr. J. L. Snyder, M. M. E., Cornell University, has been appointed an assistant in the Engineering Laboratory. Mr. A. R. Nottingham is filling Mr. Eyre's place for one year as instructor in Mechanical Engineering. Professor A. W. Cole has become responsible for the administration of Thermodynamics. Professor H. S. Dickerson has taken charge of Steam and Gas Power as administered to the civil engineers.

GIFTS TO THE SCHOOL

A four cylinder automobile motor, donated by the Nordyke, Marmon Company, manufacturers of the Marmon automobile, has been set up in the gas engine laboratory, and is being used in thesis work. The American Foundries Company has given a complete freight car truck to be used in experimental work. Numerous other valuable material has been donated by a large number of firms, such as carburetors, samples of steam turbine blading, bars of spring steel, jacks, separator models, oil samples, catalogue and filing case, and a variety of data in the form of drawings, blueprints, and tabulated results.

NEW EQUIPMENT

The school has acquired a small amount of new apparatus within the past year. An electric pyrometer complete with thermo couples for high temperatures has been bought. At the present time, a belt testing apparatus is being constructed in the Purdue shops, which will contain some novel features. A flue gas analysis outfit has been obtained and has found much use in the boiler test in the power house. Water weights for automatically weighing and recording weights of water has been added to the equipment.

RESEARCH WORK

Quite a number of problems connected with the automobile is being investigated at the present time. An attempt is being made to determine the road and wind resistances. Tests are being run on kerosene carburetors. A study of the effect of mufflers on the power and efficiency of automobile motors has been in progress for the last two years. A series of comparative carburetor tests is being conducted this spring. Work leading to the determination of the power and fuel consumption of electric lighting and starting systems has been started. The study of lubricating oils is being continued. A number of interesting problems are still under investigation, such as the fixing of the tar forming temperatures of American coals; the adapting of a suction gas producer to bituminous coals; and the determination of the coking qualities of American coals.

SCHOOL OF ELECTRICAL ENGINEERING

NEW HIGH POTENTIAL LABORATORY

A new laboratory for high potential research has been installed during the past year in the room previously used for laboratory calculations. This laboratory is now equipped with the 300,000 volt transformer constructed by students as thesis work in 1909 which is connected with high tension tubular bus bars running the entire length of the room on suspension insulators. These bus bars may be connected through wall bushings to the experimental high tension transmission line or to other high tension apparatus to be tested in the laboratory. Seniors this year are constructing standard sphere and needle spark gaps for the measurement of high potentials and a large parallel plate condenser consisting of ten plates of galvanized iron each 4 feet by 5 feet has also been constructed for the purpose of investigating the electrostatic field at very high voltages. Research work in connection with corona loss on the experimental high tension line is being continued this year and another study of the comparison of the actual and theoretical interference between high tension line and telephone line is also being undertaken.

CALIBRATION LABORATORY

The room previously occupied by the high potential laboratory has been very completely equipped for calibration work. This has been particularly necessary because of the standardization work which is to be done in the near future for the Public Utility Commission.

NEW COURSE IN PUBLIC CORPORATION MANAGEMENT AND REGULATION

Owing to the demand for technical graduates for commercial and executive positions a new elective course covering the organization, management and regulation of public utilities will be established during the coming year. This course will give the students some idea of the financial and accounting problems involved in the management of public utility corporations and their appraisal and regulation as carried on by the various state public service commissions.

PERSONNEL

Professor Alfred Still, the prominent English engineer who held a tentative position on the staff during the second semester of last year, has now joined the permanent staff of the School of Electrical Engineering as assistant professor. Prof. D. D. Ewing, formerly head professor of the electrical and mechanical departments at Ohio Northern University, who was engaged in graduate work here last year has also been made assistant professor on the permanent staff. Mr. R. V. Achatz, of the 1908 class who has since graduation been engaged with the A. T. & T. Co., in operating and appraisal work as well as with the B. J. Arnold Co., of Chicago, is now instructor in telephone engineering and assistant in the general laboratory work. Mr. J. B. Sheadel, of the 1911 class, is acting as assistant in the laboratory during the present year.

SCHOOL OF CIVIL ENGINEERING

ENGINEERING CAMP

A new course in civil engineering is to be put in operation with the present sophomores, who will attend an engineering camp from June 6th until July 4th. The state forest reserve, in Clarke County, Indiana, about twenty miles north of Louisville, has been chosen for the camp on account of its great variety of topographical conditions. The tract comprises 4,000 acres and is nearly five miles in length. Through it runs a chain of hills, with knobs elevated about 500 feet above the valleys. The sleeping headquarters are situated on one of these knobs that commands a wide and beautiful view over the valley of the Ohio river. The students will lead a camp life in all respects. The work will comprise geodetic and astronomical surveys, topographical, railway and highway surveying.

SERVICE TO STATE

The school exercises an increasing activity in the state and in municipalities. It is coming to occupy the same position in the state with respect to the problems of water supply, sewage disposal, road and bridge construction, and drainage, that the school of agriculture does to the problems of agriculture. The second engineering conference of county officials was held at the school this year, and resulted in the passage of a resolution calling upon the state to establish a good roads school at Purdue University for the newly created road officials, to last ten days each year.

CHANGES IN COURSE

A special course in highway engineering has been established in the senior year, and it is expected that an assistant professorship of highway engineering will be established. In this way the school will be able to comply with the increasing number of requests for cooperation and extension teaching for highway engineering. The establishment of the engineering camp has made possible the increasing work in hydraulic engineering. Fundamental hydraulics and hydraulic laboratory will be taken by the junior civil engineers, and a larger course in hydraulic motors will occupy the first semester of the senior year.

A course of general lectures upon the history of distinguished engineers and descriptions of notable engineering constructions will be given to the juniors in the first semester.

SPECIAL RESEARCH

In the hydraulic laboratory the research work on the frictional resistance of sand-carrying water has been completed, and is being prepared for publication. At the request of the President of the American Waterworks Association tests are being made of the strength and failure of lead pipe and the brass fittings usually employed in house connections to water mains. The pipe varies from ¾ of an inch to 2 inches in diameter and the various weights of pipe are all included. In the laboratory for testing materials the investigation of reinforcing bars rerolled from steel rails was carried on for the American Society for Testing Materials, and reported to the association. Professor Sackett of the hydraulic department has been active in the flood protection work of the state. Professors Hatt and Smith have served on the board of engineers for the construction of the new Main Street bridge. Professor Sackett has been appointed a member of the Board of Public Works of the City of Lafayette. Professors Garman and Case have left the University to take on new responsibilities. Professor Garman becomes chief engineer of the Public Utilities Commission, and Professor Case becomes Professor of Sanitary Engineering at Pittsburgh University.

SCHOOL OF CHEMICAL ENGINEERING

DESCRIPTION OF COURSE

The Purdue catalogue of 1906-07 contained the first announcement of a course in chemical engineering, and the first graduate from this course received his diploma in 1910. The School of Chemical Engineering was established in 1911 and now has an enrollment of 139, a graduating class of 13, and 35 alumni. The school was established to meet a demand which has resulted from the increasing application of chemical principles to engineering problems and manufacturing processes. The rapid development of the strictly chemical industries, as well as recognition by engineers of the importance of the chemical aspects of their particular problems, has emphasized the demand for men so trained as to combine the functions of both chemist and engineer. To meet these requirements, a course of study is necessary, which includes, with mathematics, physics, and their applications in engineering, a thorough knowledge of chemistry. The course as laid down at this institution, is a general course in engineering and chemistry, with no attempt to specialize in any direction. The chemical engineer, therefore, occupies a middle ground between the engineer and the chemist, with the advantage over the former of chemical training and over the latter of a knowledge of engineering. His training is a preparation for such positions as chemist, engineer, or manager in those industries which involve the application of chemical and engineering principles, or for positions along engineering lines where a knowledge of chemistry is necessary. In the development of the plan of study of this school probably the most noteworthy point brought out is the advantage arising from the general nature of the course, resulting in a broadening of the young engineer's sphere of activities and increasing his opportunities.

THE

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ENGINEERING REVIEW

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FLOOD PROTECTION IN INDIANA*

By W. K. Hatt,

Professor of Civil Engineering

The appointment of the Indiana Flood Commission was the direct result of the flood of March, 1913, in which 467 lives were lost and over $160,000,000.00 of property destroyed in the United States. The memory of this catastrophe is still fresh in the minds of the people of Indiana, in which State 39 lives were lost, and over $25,000,000.00 of property destroyed.

The total loss in the flood of March, 1913, can never be known. The interruption of transportation and of business, the destruction to farm lands by cutting of banks of rivers and covering of bottom lands with gravel, the loss of productive capacity of manufacturing plants, and the sickness following exposure, are not susceptible of exact computation.

Professor Beede of Indiana University reports a total damage of approximately one-half million dollars, in seven counties in the lower White River basin, in which also nearly eight thousand acres of agricultural land were denuded of soil and some sixteen thousand acres of river bottoms were covered with sand and silt. He estimates the loss to agricultural land in this region as nearly $250,000.00.

Part of the damage to country roads and bridges reported by the county auditors was over $3,000,000.00. Other tangible losses that have been determined are shown in Table 1. It is probable that other losses during the flood of March, 1913, in Indiana will bring the total losses to more than $25,000,000.00.

Indeed the catastrophe was so general over the Ohio Valley that it excited the sympathy and support of the entire nation. The Governor of the State of Indiana received $141,088.96 in subscriptions for the relief of flood sufferers in this State.

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*Condensed from Bulletin No. 4, Bureau of Legislative Information; written by Professor Hatt.

TABLE NO. 1.

PART OF DAMAGES SUSTAINED IN INDIANA IN THE FLOOD OF MARCH, 1913

1.	County Highways and Bridges	$2,825,240.00
2.	Railroads—Steam	5,299,810.00
3.	Electric Railways	788,000.00
4.	Buildings and Personal Property	8,104,250.00
5.	Telephone and Telegraph	200,000.00
6.	Crops	735,700.00
7.	Live Stock	149,380.00
8.	Farm Lands (part of White river only)	247,500.00
9.	Suspension of Business	582,000.00
	Total	$18,949,390.00

Counties not included in (1)
Cass,
Floyd,
Clinton,
Miami,
Fayette,
Sullivan.

Railroads not included in (2).
Central Indiana R. R.
Chicago and Wabash R. R.
Cin. Ham. and Dayton R. R.
Toledo, Peoria and West'n R. R.
Toledo, St. L. and West'n R. R.

Electric lines not included in (3).
Marion and Bluffton Trac. Co.
Bluffton, Geneva and Celina Trac. Co.
Central Indiana Lighting Co.
Indianapolis Street Ry. Co.
Louisville and Southern Trac. Co.
Louisville and Northern Ry. and Light Co.
Vincennes Trac. Co.
Washington Street Ry. Co.

(5) Includes Indianapolis Telephone Co. and Central Union Telephone Co.

Counties in Flood Districts not included in (4), (6), (7) and (9).

Adams,
Blackford,
Cass,
Clark,
Clay,
Clinton,
Fayette,
Floyd,
Fountain,
Franklin,
Gibson,
Grant,
Greene,
Harrison,
Howard,
Huntington,
Jay,
Jefferson,
Ohio,
Parke,
Perry,
Putnam,
Randolph,
Ripley,
Scott,
Sullivan,
Switzerland,
Tippecanoe,
Vanderburg
Vermillion,
Vigo,
Wabash,
Warrick,
Wells,
White,
Whitley.

(8) Includes loss only in 230 miles of East and West Forks of the White River through Morgan, Owen, Greene, Daviess, Knox, Jackson, Lawrence and Martin Counties.

FORMER FLOODS IN INDIANA

Floods have occured in Indiana as far back as records are obtainable. In the early days, before levees had been raised above high water, and before cities had been built in the bottoms, the losses were small, and people did not have to pass over the river until the flood waters subsided.

In recent years the effects of similar floods have become more serious, and the problem has become acute. It has been made so by the inevitable encroachments on the flood plains and bottoms which were formerly given up to the rivers during floods, while at the same time, channels have not been improved in proportion to the encroachment.

Serious floods may occur at any time throughout the year, but they usually happen between December and April. January, February, and March are the months when the combination of rainfall and surface conditions produce the worst effects.

The following floods have been state wide in Indiana:

January, 1847—Rainfall.
June, 1857—
September, 1866—Series of heavy thunderstorms.
August, 1875—Heavy rains following wet summer.
February, 1883—High monthly precipitation with thaw.
March, 1897—Series of excessive rains.
March, 1904—Series of storms.
February, 1908—Moderate rain with thaw.
October, 1910—Single protracted storm.
January, 1913—Single protracted storm.
March, 1913—Two protracted storms, practically one.

CHARACTERISTICS OF FLOODS

A heavy storm, shedding long continued rain, sweeps up the Ohio Valley, and finds the ground frozen or covered with snow, the subsoil saturated and the channels already charged with water, so that the greater part of this rainfall runs off through the streams.

The tributaries may all be discharging and attempting to find outlet at the same time, through the main channel, in which people have been dumping refuse, constructing levees and buildings that add to the height of flood waters.

The meteorological conditions attending serious floods are made clear in Diagrams 1 to 4. A storm starts in the southwest and follows up a trough of low pressure between

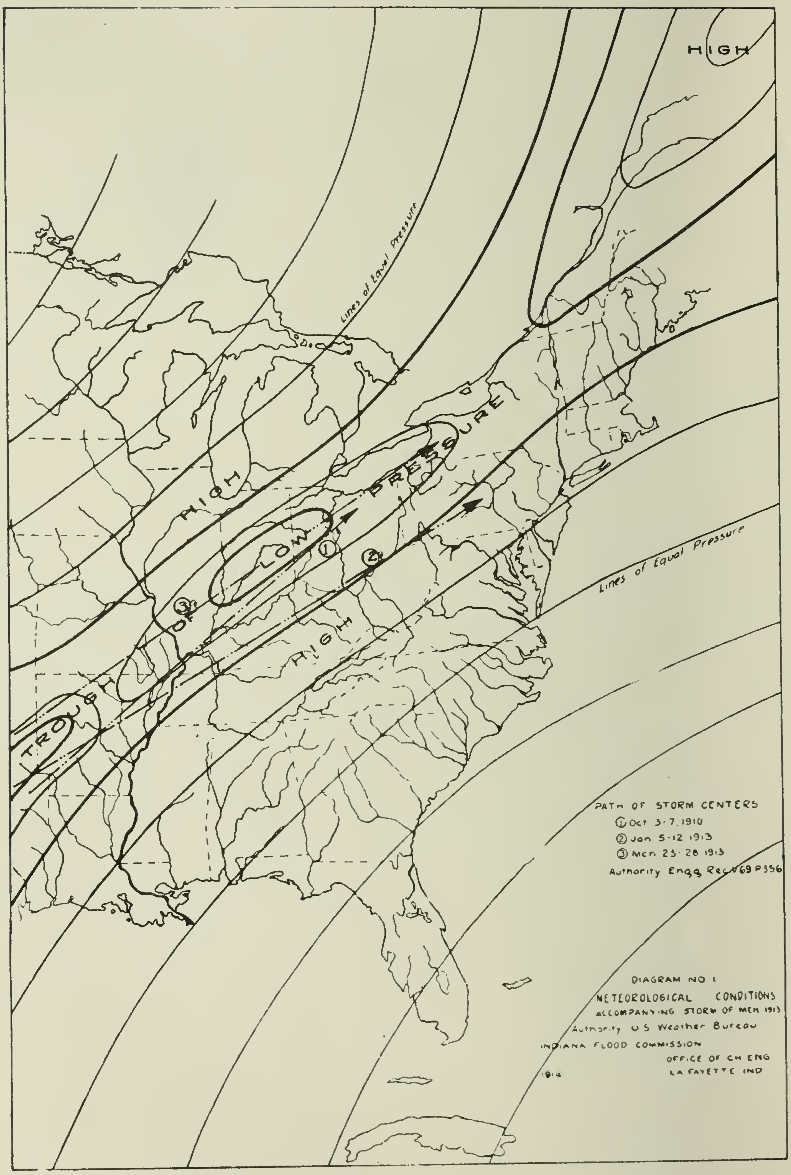
HIGH
Lines of Equal Pressure
HIGH
LOW
PRESSURE
①
②
③
OF
TROUGH
HIGH
Lines of Equal Pressure
PATH OF STORM CENTERS
① Oct 3-7, 1910
② Jan 5-12 1913
③ Mch 23-28 1913
Authority Engg Rec V69 P356
DIAGRAM NO 1
METEOROLOGICAL CONDITIONS
ACCOMPANYING STORM OF MCH 1913
Authority U S Weather Bureau
INDIANA FLOOD COMMISSION
OFFICE OF CH ENG
LA FAYETTE IND
1913

Diagram No. 1.

two high pressure areas on either side of the Ohio Valley. Sometimes a second storm follows up the first immediately, and it is a further burden upon the overtaxed channels. (See Diagram 1.)

Records are available of three notable past storms, (shown in Diagrams 2 to 4) that of October, 1910; that of January, 1913; and that of March, 1913; characterized by a heavy intensity of rainfall over large areas, the two latter coming at the time of year when very little of the rainfall was absorbed in the ground.

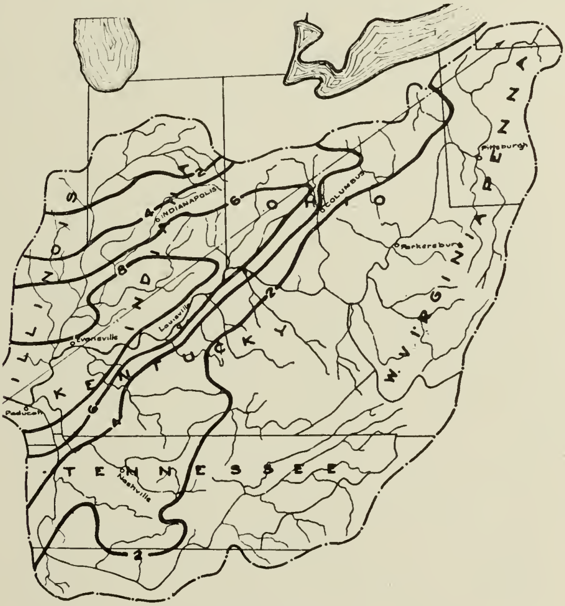

Diagram No. 2.

As we shall see later, storms such as these are a measure of the amount of river discharge that flood protection works must carry.

Diagram 1 shows the paths taken by these three excessive storms. The northern portions of Indiana lie outside the track of these storms. For example, the Eel River and the Tippecanoe River are not likely to receive as heavy rainfall as the East and West Forks of the White River, because the latter lie in the path of these severe storms.

Diagrams 5 and 6 are drawn to show the inches of rainfall that fell at various localities affected by the storm. It is plain that large areas receive a less average rainfall than small areas. For instance, in Diagram 5, we find that in January, 1913, an area of 500 square miles had a rainfall in excess of eleven inches; an area of 2,500 square miles had a rainfall in excess of ten inches; and an area of 14,500 square miles had a rainfall in excess of eight inches. From a study of the three storms, Diagram 7 has been prepared to show the relation between an area of given size in a watershed, that lies in the path of these storms, and the amount of rain that may reasonably be expected on this area.

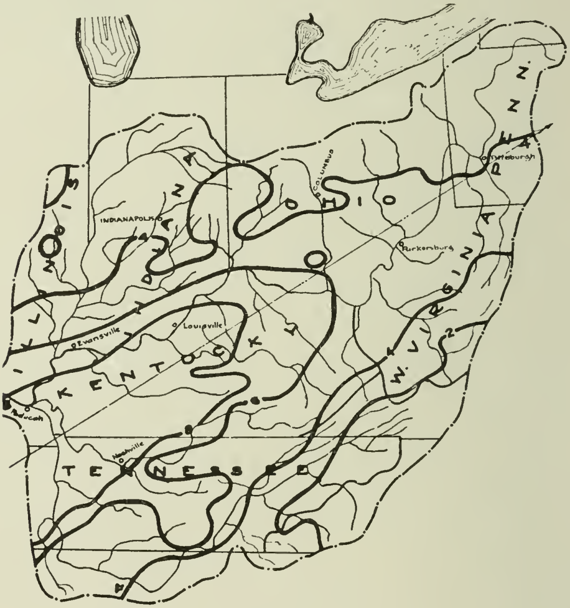

Diagram No. 3

Possible Future Storms

The storm of March, 1913, was not as heavy as either that of January, 1913, or that of October, 1910. Of course a combination of the storm of January and a snow-covered surface is possible, and would have caused a flood greatly in excess of that of March. It is fortunate that these storms sweep up the Ohio Valley instead of down, because the latter storm would tax the channel more severely than the former.

Of course, small areas in any part of the State may receive a heavy local rainfall, at any time of the year, and bridge openings must provide for this rainfall. For instance, in the Muskingum Valley an unprecedented rain-storm occurred in July, 1913, following the flood of March, 1913, causing flood heights higher than those of the previous storms. At one station a rainfall of 7.17 inches was recorded for a period less than nine hours.

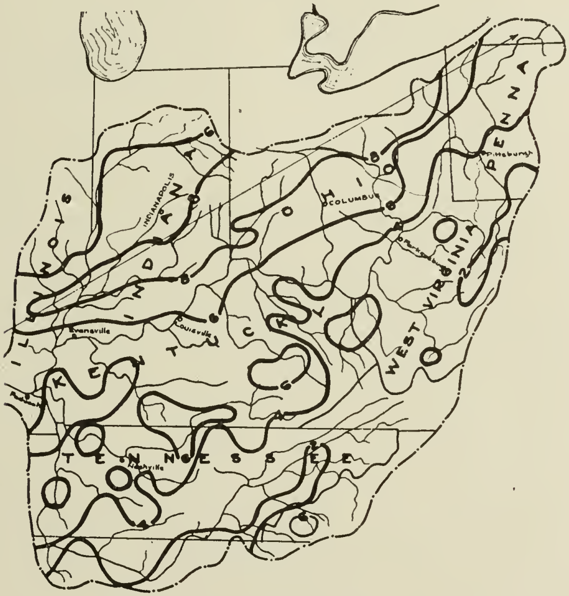

Diagram No. 4

But we are now speaking of storms that cause widespread floods over an entire watershed, and trying to estimate what rainfall we should provide for in improved channels and under bridges in plans for flood protection works.

A simple method is to specify that these works shall carry the rainfall of March, 1913, which caused the greatest flood on record, and then add to this an arbitrary increase of one-third in the White River and a less amount in the more northerly watersheds further removed from the path of extraordinary storms.

Diagram 6 shows (Lines a) the actual rainfall that occurred in the Wabash Valley and the two forks of the White River in March, 1913, and also (Lines b) the rainfall that would have fallen if the March storm had been increased by a factor of one-third on the White River, and a factor of one-fourth on the Wabash River. This increased rainfall on the East Fork of the White River and the lower Wabash River is nearly the same as that which would have occurred if the storm of January, 1913, had followed a path 75 miles farther north.

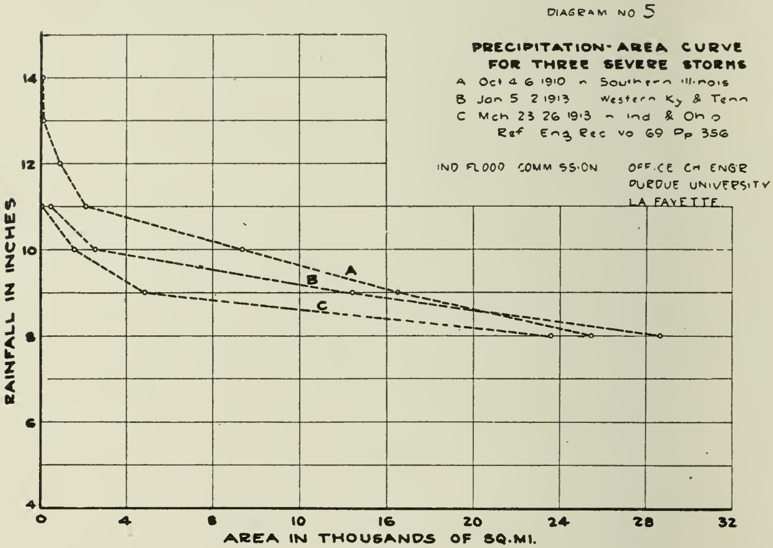

Diagram No. 5

Of course if such a storm as that of October, 1910, were arbitrarily shifted to a path over the headwaters of the Wabash, extraordinary conditions would be found. As a matter of fact, however, the centers of these storms causing severe floods in Indiana do not pass this far north. It would be unreasonable to predict a rainfall intensity in northern Indiana and impose a factor of safety against future contingencies, as high as equal areas receive in the White River Valley.

Conclusion as to Rainfall

In general, then, we may reasonably require that the constructions for flood protection works on the Wabash and the White Rivers should provide for the rainfall shown by the lines in Diagram 7.

Periodicity of Rainfall

A curious relation between the amounts of rainfall through cycles of years is evident from Diagram 8 which shows the distribution of yearly rainfall since 1830. The cycle of 34 years from a period of excessive rainfall to deficient rainfall is evident in the region around Cincinnati. On the basis of this Diagram, some are inclined to predict heavy floods in the near future. They say that we have been passing through a series of years of deficient rainfall in conjunction with increased farm drainage and growing encroachments upon stream channels, and that excessive floods are indicated for the near future.

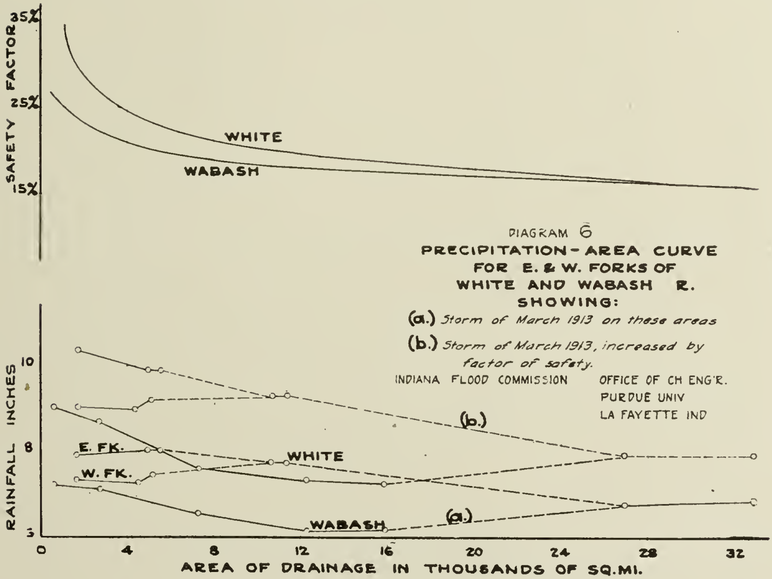

Diagram No. 6

Inasmuch as the great floods occur in the months of January to March, inclusive, similar periodicity Diagrams have been drawn for these months, (See Diagram 9) and the close connection between the excessive rainfall and severe floods is evident.

These Diagrams (8 and 9) show progressive averages, that is to say, to obtain the rainfall for any year, the rainfall of the previous year and succeeding year are averaged along with the rainfall of the year in question. The latter is given double the weight of the others in this average.

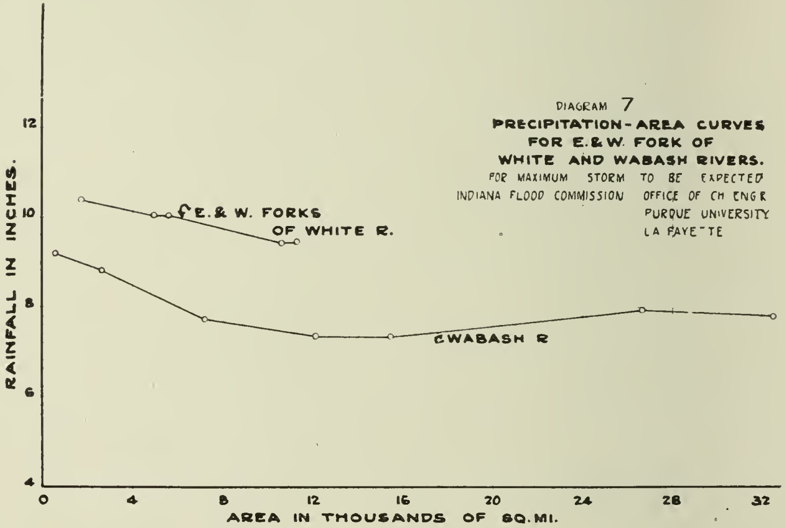

Diagram No. 7

RAINFALL AND STREAM DISCHARGE

How much of this rainfall will discharge in the rivers? Only a part of the rain that falls on the upper reaches of a watershed ordinarily runs by a city below. Great floods occur when the greater part of the rainfall runs off in the streams during the extraordinary storms.

Part of the rainfall is held back for a time in porous subsoil, in swamps, and in the ground surface, especially in forest cover, and is let out gradually.

Part of the water also disappears through evaporation and is used by vegetation.

For instance, in the former days before land was drained for agriculture, the heavy rains of the winter and spring were held back in the swamps and other natural detaining agencies, until near mid-summer.

There was higher water in the streams throughout the summer than at present, and the ordinary workings of the river were more even.

There is no doubt but that, because of the cutting down of the forests and the draining of the swamps, and the construction of large drainage systems for farm lands, the rain now runs more rapidly to the watercourses, and the height between ordinary high and low water is greater. These new conditions must cause more frequent floodings of our river bottoms.

But these tremendous floods like March, 1913, are due to severe storms that send rain down upon the surface when the soil is already as full as a wet sponge, or frozen, or when there is snow on the ground. Even if the swamps and forests were in existence, they would have had no further capacity left to take this heavy rainfall. It would have run quickly into the streams as it does now.

Then, too, in early times, the bottoms of the rivers were grown up in thick forests which offered great resistance to the free flow of flood waters over the bottoms outside of the river channel.

Those who have given close study to the matter are not able to find evidence that the flood heights during these extreme floods are higher than flood heights in early days, except in the cities and other localities where the embankments, levees, buildings and bridges have made local obstructions that dam up the waters, and create a head of back water.

One serious problem in Indiana at present is the control of future obstructions to the free flow of flood water in our streams, and to remove present obstructions that will interfere with the building of flood protection works by our cities.

DETERMINATION OF RIVER DISCHARGE

The part of the rainfall that runs off into the streams, that is, the "runoff,' is expressed as river discharge. The shape of the watershed whether long and narrow, or short and wide, and the character of the surface, whether rocky or with deep gravel sub-soil, and the convergence of the side tributaries and the steepness of the watershed, each has its own particular effect on the rate at which the runoff reaches the river channel.

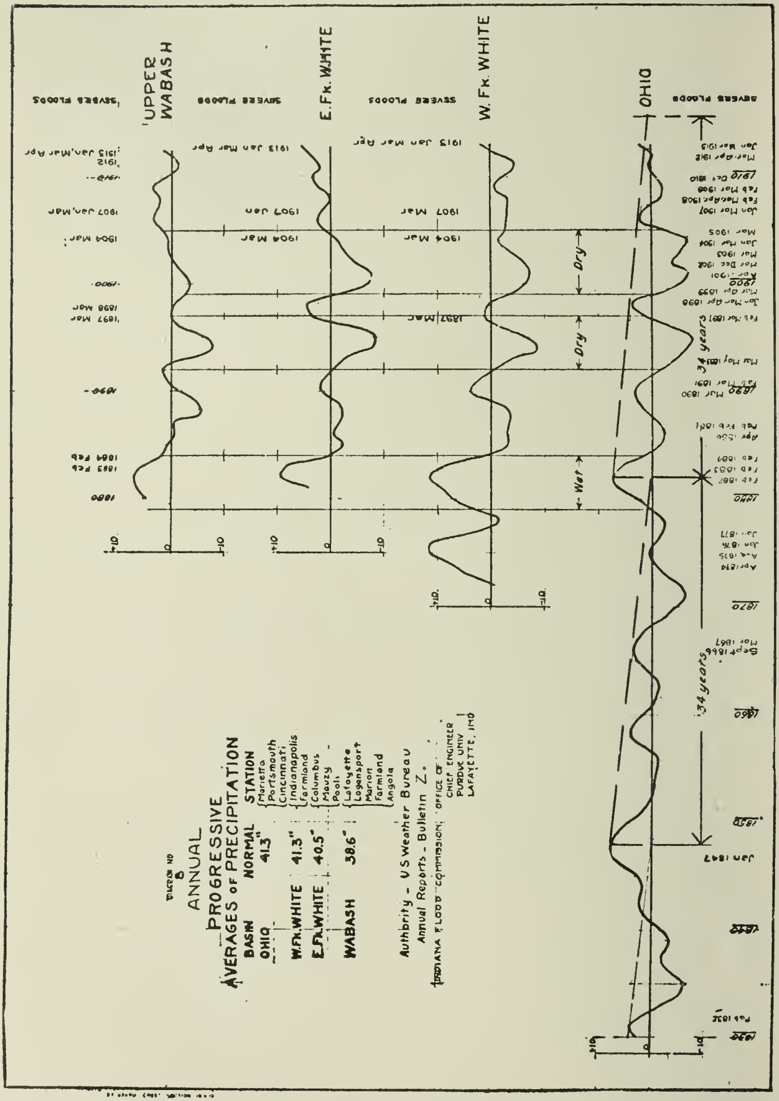
UPPER WABASH
E. FK. WHITE
W. FK. WHITE
OHIO
SEVERE FLOODS
Dry
Dry
Wet
34 years
34 years
DIAGRAM NO 8
ANNUAL PROGRESSIVE AVERAGES of PRECIPITATION
BASIN NORMAL STATION
OHIO 41.3" Marietta Portsmouth Cincinnati
W.FK.WHITE 41.3" Indianapolis Farmland
E.FK.WHITE 40.5" Columbus Mauzy Pooli
WABASH 38.6" Lafayette Logansport Marion Farmland Angola
Authority - U S Weather Bureau Annual Reports - Bulletin Z.
INDIANA FLOOD COMMISSION OFFICE OF CHIEF ENGINEER PURDUE UNIV LAFAYETTE, IND

Diagram No. 8

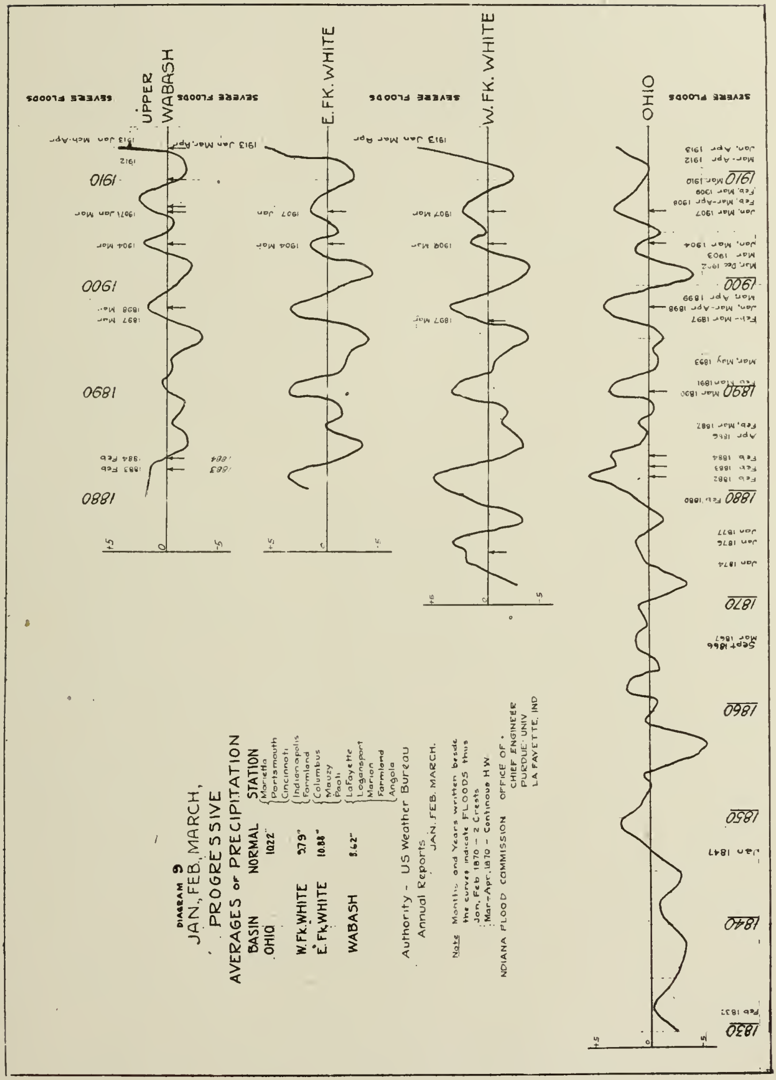
DIAGRAM 9
JAN, FEB, MARCH,
PROGRESSIVE
AVERAGES OF PRECIPITATION
BASIN NORMAL STATION
OHIO 10.22" Marietta Portsmouth Cincinnati
W. FK. WHITE 9.79" Indianapolis Farmland
E. FK. WHITE 10.88" Columbus Mauzy Paoli
WABASH 8.62" LaFayette Logansport Marion Farmland Angola
Authority - US Weather Bureau Annual Reports
JAN. FEB. MARCH.
Note Months and Years written beside the curves indicate FLOODS thus
Jan, Feb 1870 - 2 Crests
Mar-Apr, 1870 - Continous H.W.
INDIANA FLOOD COMMISSION OFFICE OF CHIEF ENGINEER PURDUE UNIV LA FAYETTE, IND
UPPER WABASH
E. FK. WHITE
W. FK. WHITE
OHIO
SEVERE FLOODS
+5
0
-5
1830
1840
1850
1860
1870
1880
1890
1900
1910

Diagram No. 9

A long narrow watershed will not deliver rainfall as quickly to a point in the channel below as will a short and compact watershed.

The difficult problem is to compute the river discharge at any city arising from the rainfall on the watershed above.

Certain formulas have been proposed by which the river discharge may be computed. For instance, Mr. W. E. Fuller's formula, (Proc. Am. Soc. Civil Eng., Vol. 39, p. 1012) is

$$Q = CA^{0.8}$$

where Q is the average yearly flood, in cubic feet per second; C is the coefficient which is constant for the river at the point of observation; A is the catchment area of river in square miles.

Mr. Fuller remarks that the largest flood occurring in one hundred years will be 2.6 times the average yearly flood. This subject is now under lively discussion by engineers and other formulas are proposed, but all of these must depend upon the measurements of river discharge, which are lacking for conditions in Indiana.

The only certain method is to actually measure, by well known methods and tried instruments, the discharge of our rivers through a long term of years. Many States have done this in co-operation with the United States Geological Survey. Then the engineer will know the number of cubic feet per second of river-discharge for which flood protection works must be designed.

But we have made so little progress in scientific study of our streams that we are seriously handicapped in studies for flood protection.

Certainly one important effort that the State of Indiana must exert in the future is to provide for these streams gagings through a co-operative agreement with the United States Geological Survey, which has trained men and the instrumental equipment to perform this work efficiently.

These stream gagings would, however, require a long term of years for their completion.

Meanwhile many of our cities are in increasing danger from floods. In some cities the situation is acute and the people can not wait for a complete determination of scientific data before planning flood protection works.

For immediate purposes and in the absence of full information, the following method of solving the problem will be found useful and reasonably satisfactory.

Briefly, the method consists in finding the river discharge at selected points, the rainfall in the valleys above

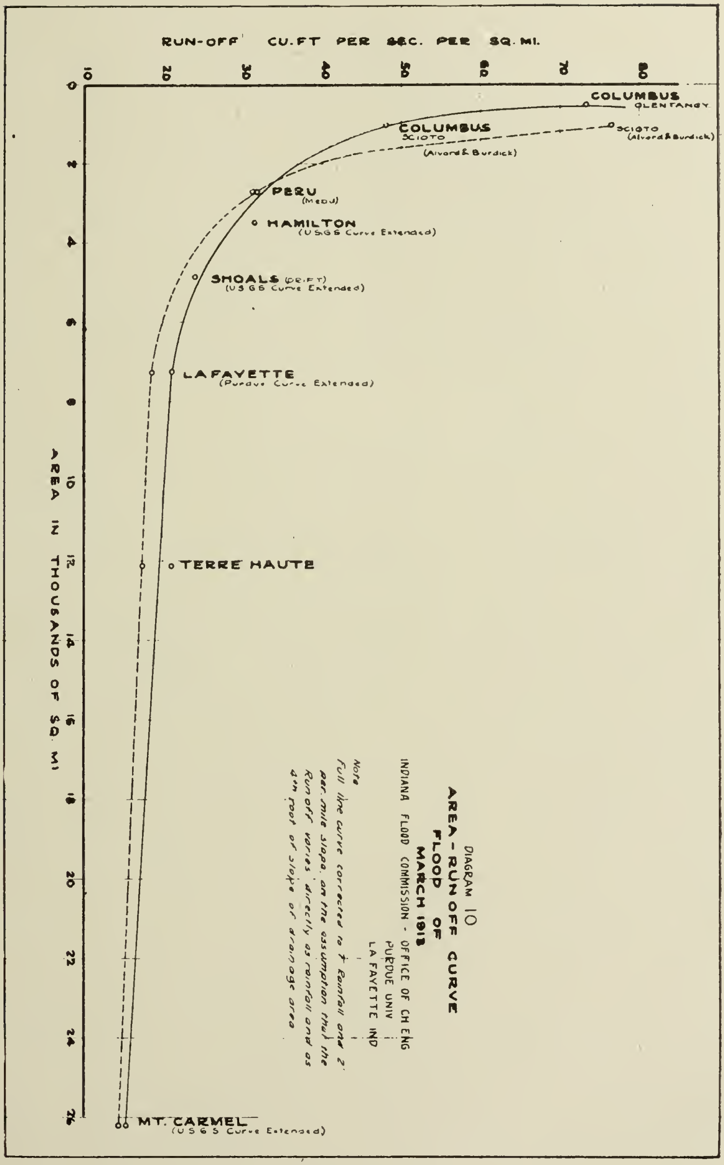

Diagram No. 10

these points during the flood conditions of March, 1913, the general slope of the drainage area, and then to apply these measurements to watersheds of like character.

Diagram 10 shows our best information of river discharge in March, 1913. The number of cubic feet per second flowing from a square mile of watershed is shown in dashed line. These all had different slopes of watershed. In full line the measurements have been adjusted to a standard rainfall of seven inches, and to a standard average slope of watershed of 2 feet per mile.

The full line may be used with a reasonable degree of certainty to predict river discharge for the White River and the Wabash River watersheds in Indiana, after making allowance for the expected rainfall and the slope of the watershed.

For example, the area of the White River watershed above Indianapolis is 1680 square miles, for which area Diagram 10 provides a discharge of 39.5 cubic feet per second per square mile, (that is for a rainfall of seven inches and a standard slope of the drainage area of two feet per mile). But the expected rainfall for 1680 square miles is (Diagram 7) 10.35 inches. The fall from the rim of the watershed to Indianapolis is 450 feet in a length of 83.5 miles, and therefore the average slope of the bed of the drainage area is 5.40 feet per mile on an average.*

To find what river discharge Indianapolis may reasonably expect to pass through its flood protection works, we must increase the rate of discharge of 39.5 cubic feet per second per square mile, above mentioned, in proportion to the probable rainfall and also increase it as the fourth root of the slope. Our computation is then as follows:

$$39.5 \times \frac{10.35 \times}{7} \sqrt[4]{\frac{5.40}{2}} \times 1680 = 125{,}580 \text{ cu. ft. per second.}$$

OPENINGS REQUIRED TO CARRY RIVER DISCHARGE

The civil engineer is able to calculate the size of channel and the length of bridge opening to carry the river discharge. He must take into account local conditions, including the slope of the river bed, the alignment of the channel, whether straight or crooked, and the character of the ma-

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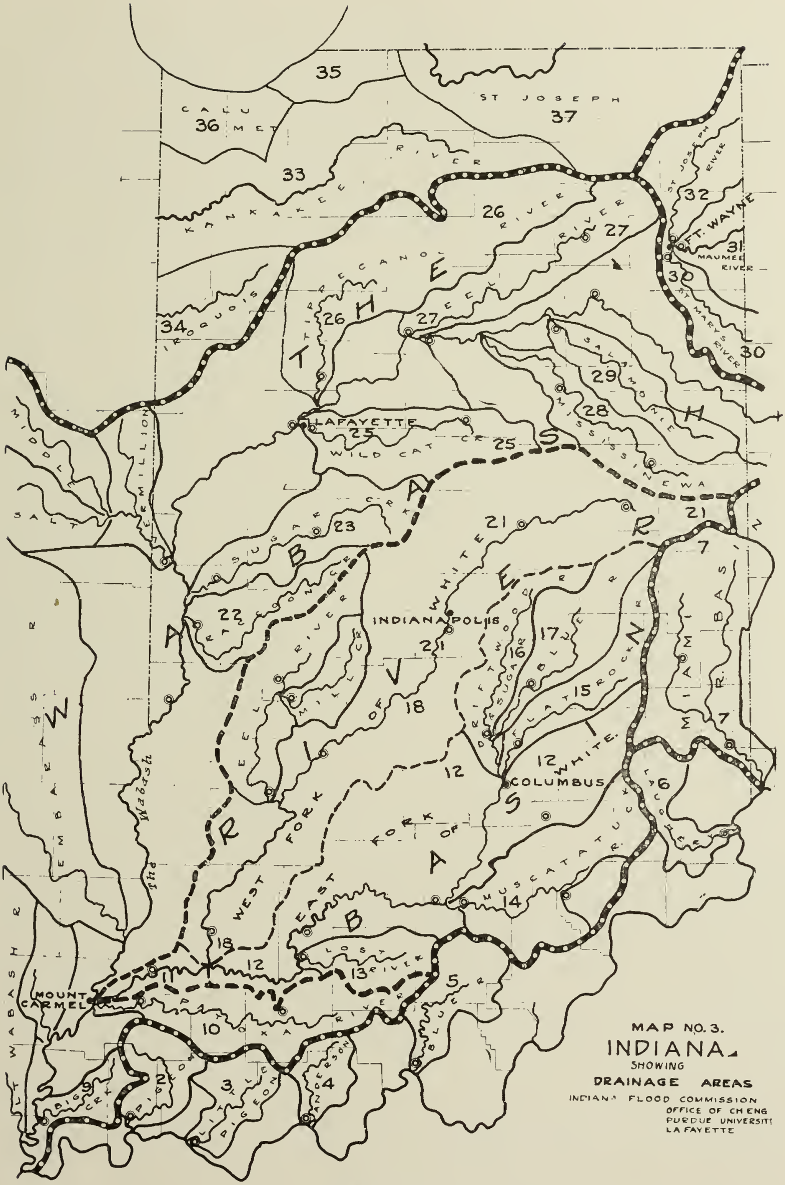
*The slope of the river channel is less than the slope of the drainage area. For the White River above Indianapolis the average channel slope is 3.41 feet per mile.


MAP NO. 3.
INDIANA
SHOWING
DRAINAGE AREAS
INDIANA FLOOD COMMISSION
OFFICE OF CH ENG
PURDUE UNIVERSITY
LA FAYETTE
THE WABASH RIVER BASIN
35
CALUMET
36
ST JOSEPH
37
KANKAKEE RIVER
33
IROQUOIS
34
TIPPECANOE RIVER
26
EEL RIVER
27
ST JOSEPH RIVER
32
FT. WAYNE
31
MAUMEE RIVER
30
ST MARYS RIVER
SALAMONIE
29
MISSISSINEWA
28
LAFAYETTE
25
WILD CAT CR
MIDDLE
SALT
VERMILLION
SUGAR CR
23
RACCOON CR
22
EEL RIVER
MILL CR
21
WHITE
INDIANAPOLIS
18
WEST FORK OF WHITE
DRIFTWOOD R
SUGAR
16
BLUE R
17
FLATROCK
15
WHITE
12
COLUMBUS
EAST FORK OF WHITE
MUSCATATUCK R
14
LAUGHERY
6
MIAMI R
MIAMI BASIN
7
EMBARRAS R
WABASH R
The Wabash
MOUNT CARMEL
11
LOST RIVER
13
5
BLUE R
PATOKA RIVER
10
ANDERSON
4
LITTLE PIGEON
3
PIGEON
2
BIG CRK
9

Map No. 3

A COMPARISON OF DRAINAGE AREAS

STREAM	AREA Square Miles				Per Cent. of State	Percentage Taken Separately			Total Length of River	Mean Slope of Drainage Area	Rainfall, 23–27, Mar., 1913
	Illinois	Indiana	Ohio	Total							
									Miles	Ft. to Mile	In.
WABASH SYSTEM	9,028	23,829	358	32,215	66.1	100.0	-----	-----	-----	-----	6.8
White River*	-----	11,281	-----	11,281	31.2	47.3	100.0	-----	-----	-----	7.8
West Fork	-----	5,371	-----	-----	14.8	-----	47.6	100.0	-----	2.22	7.5
Eel River	-----	925	-----	-----	2.5	-----	-----	17.2	91	5.47	6.4
Mill Creek	-----	285	-----	-----	0.8	-----	-----	5.3	51	5.01	5.25
Other Streams	-----	4,161	-----	-----	11.5	-----	-----	77.5	-----	-----	-----
East Fork †	-----	5,910	-----	-----	16.4	-----	52.4	100.0	-----	4.22	8.1
Lost River	-----	348	-----	-----	1.0	-----	-----	5.9	70	11.71	7.8
Muscatatuck River	-----	1,108	-----	-----	3.1	-----	-----	18.7	52	6.0	8.4
Flat Rock River	-----	516	-----	-----	1.4	-----	-----	8.7	88	5.7	9.7
Driftwood River ‡	-----	549	-----	-----	1.5	-----	-----	9.3	72	5.8	7.5
Blue River	-----	644	-----	-----	1.8	-----	-----	10.9	74	5.7	8.00
Other Streams	-----	2,745	-----	-----	7.6	-----	-----	46.5	-----	-----	-----
Wabash River	9,028	12,548	358	21,934	34.9	52.7	100.0	-----	482	1.39	6.2
Big Creek	-----	198	-----	-----	0.5	-----	1.6	-----	40	3.95	6.0
Patoka River	-----	895	-----	-----	2.6	-----	7.2	-----	148	2.26	7.5
Raccoon Creek	-----	519	-----	-----	1.4	-----	4.1	-----	65	12.00	8.4
Sugar Creek	-----	519	-----	-----	1.4	-----	4.1	-----	65	12.00	8.4
Sugar Creek	-----	875	-----	-----	2.3	-----	7.0	-----	80	6.56	5.64
Wild Cat Creek	-----	769	-----	-----	2.1	-----	6.1	-----	64	5.92	6.5
Tippecanoe River	-----	1,889	-----	-----	5.2	-----	15.0	-----	133	3.22	4.96
Eel River	-----	864	-----	-----	2.4	-----	6.9	-----	79	3.23	5.5
Mississinewa River	-----	855	-----	-----	2.4	-----	6.8	-----	124	3.1	8.08
Salamonie River	-----	528	-----	-----	1.5	-----	4.2	-----	85	6.7	7.0
Other Streams	-----	5,086	-----	-----	14.1	-----	40.5	-----	-----	-----	-----
Little Wabash River	3,517	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Embarras River	2,367	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Vermilion River §	1,538	70	-----	1,608	0.2	-----	0.6	-----	-----	-----	5.5
Other Streams	1,606	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
MAUMEE SYSTEM	-----	1,186	-----	-----	3.3	100.0	-----	-----	-----	-----	-----
Maumee River	-----	266	-----	-----	0.7	22.4	-----	-----	25	-----	5.36
St. Joseph River	-----	581	-----	-----	1.6	49.0	-----	-----	31	-----	5.39
St. Mary's River	-----	339	-----	-----	1.0	28.6	-----	-----	39	2.8	7.31
OHIO SYSTEM	-----	5,733	-----	-----	15.9	100.0	-----	-----	351	0.3	7.0
Miami River	-----	97	-----	-----	0.3	1.7	-----	-----	-----	-----	10.17
Whitewater River	-----	1,318	21	1,339	3.7	23.0	-----	-----	‖ 17	¶	9.3
Pigeon Creek	-----	324	-----	-----	0.9	5.6	-----	-----	36	7.7	5.52
Little Pigeon Creek	-----	369	-----	-----	1.0	6.4	-----	-----	41	5.3	5.60
Anderson River	-----	273	-----	-----	0.8	4.8	-----	-----	41	13.4	5.78
Blue River	-----	452	-----	-----	1.2	7.9	-----	-----	65	6.6	6.14
Laughery Creek	-----	354	-----	-----	1.0	6.2	-----	-----	57	14.3	7.17
Other Streams	-----	2,546	-----	-----	7.0	44.4	-----	-----	-----	-----	-----
Other Streams	-----	5,297	-----	-----	14.7	-----	-----	-----	-----	-----	-----
Total Area of State	9,028	36,045	-----	-----	100.0	-----	-----	-----	-----	-----	-----
Percentage of Wabash System	27.2	71.0	1.8	100.0	-----	-----	-----	-----	-----	-----	-----

*Length, 50 miles; area, 176 square miles. † Including White. ‡ Including Sugar Creek. § Including Lt. Vermillion. ‖ East Fork, 52; West Fork, 67. ¶ E. Fork, 8.9; W. Fork, 4.5.

terial in the river bed. A steep slope with rock river-bed will permit a small channel where high velocities will not interfere with navigation.

It is impracticable to draw general rules to fit these local conditions in advance. As a rough estimate it may be stated that the velocities in improved river channels should not exceed six feet per second average velocity, and through bridge openings should not exceed eight feet per second.

For instance, in the case of Indianapolis, there is indicated on this basis an area of channel of $\frac{125,580}{6} = 20,930$ square feet, and openings through bridges of 15,700 square feet. In this case the local conditions of the streams should be studied to see if such velocities can be obtained under the hydraulic characteristics of the channel.

The Indiana Flood Commission has made a special study of bridge openings in this state, and has collected statistics showing the bridge openings in our important streams and noting whether or not they were damaged in the flood of March, 1913. This study will not only serve to determine the measure of protection of these structures, against floods, but will serve as a basis for rules to determine the proper size of bridge openings in the future.

TESTS OF STANDARD AND CLASP BRAKE RIGGING FOR PASSENGER TRAIN SERVICE

By E. F. Lickey, M. E., '09

The purpose of the following article is to give in a brief and readable manner a synopsis of the results of a series of tests made to determine the relative advantages of standard and clasp brake rigging when used in passenger train service. It should be understood that the following is a summary of the tests in which the writer was one of the engineers securing the data and afterwards formulating the same. A good portion of this article is necessarily therefore an extract of the original report submitted to the officials of the Lake Shore & Michigan Southern Railway.

Several years ago the L. S. & M. S. Ry., in common with other roads, had a great deal of trouble with slid flat wheels caused by the heavy braking pressure necessary on account of the increased weight of equipment and aided by the cold winter weather and frosty rails. It became so serious and so many passenger cars were cut out on account of flat wheels that something had to be done.

The clasp brake was proposed as a means of overcoming the trouble. This type uses two brake shoes per wheel as compared with one shoe per wheel in the standard brake rigging. The standard brake rigging has many disadvantages, among which are the following:

(a) The journal is forced out from under its bearing with resultant bad effects. This is shown in Figs. 1 and 2.

(b) Considerable side pressure of the journal box against the pedestal is produced and a consequent tendency to slide wheels.

(c) Braking force is reduced on account of a considerable horizontal travel of brake shoes with corresponding increase of piston travel.

(d) Shoe wear is very rapid and the coefficient of friction varies widely.

It was thought that the clasp brake would:

(a) Maintain more uniform piston travel and insure greater flexibility for service braking and higher cylinder pressures in emergency application.

(b) Shorten the stopping distance.

(c) Reduce the tendency to slide wheels.

(d) Prolong the life of brake shoes.

(e) Relieve the journal bearings, pedestals, etc., of unbalanced pressures tending toward displacement of parts.

(f) Improve the action of the brake in regard to smoothness and uniformity of stops.

In order to determine what advantage, if any, that the clasp brake arrangement possessed over the standard foundation brake rigging, a series of tests were made near Toledo, Ohio, by a corps of engineers representing the Westinghouse Air Brake Company and the L. S. & M. S. Ry. The writer was among the latter. Three L. S. & M. S. steel coaches equipped with P. C. Air Brake Equipment and Standard N. Y. C. Lines foundation brake rigging, and three similar cars with the same air brake equipment but with clasp brake rigging were used in the tests.

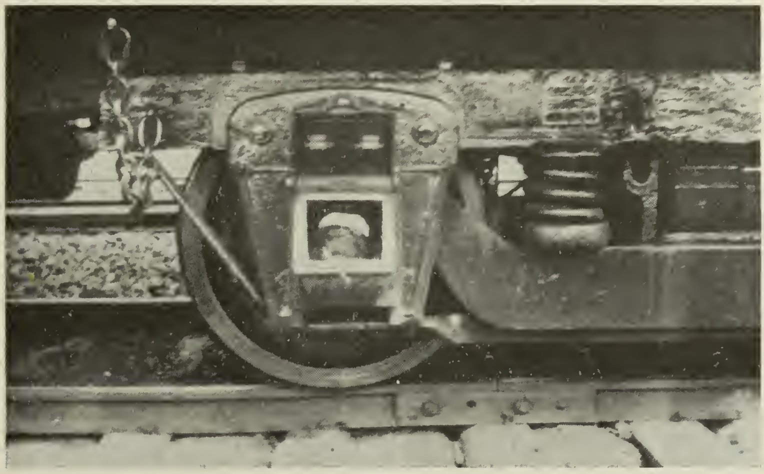


Fig. 1

The tests were made on a stretch of track picked on account of its freedom from traffic at certain hours and it being as straight and level as possible.

The track was wired with circuit breakers, the latter being connected with a chronograph in a station alongside the track. The first car was arranged with a suitable wipe to engage the circuit breakers. The engine was equipped with a trip mechanism so that it was cut off from the train and gradually pulled away from the latter when a test was made. This was necessary on account of the tests being practically all break-away; that is, the engine was cut loose from the train so as to eliminate as many variables in the weight of engine and tender as possible.

The method of conducting the tests may be of interest. Everything being in readiness the engine with train would back up several miles, the distance depending on the speed desired at the trip. They would then come ahead judging their speed from a Boyer recorder on the engine and by experience. At the trip the engine was cut loose from the train, the latter being braked by making the desired brake pipe reduction. Brake cylinder pressures were secured by indicators attached to the same, while length of stop, speed wheels slid, etc., were also secured.

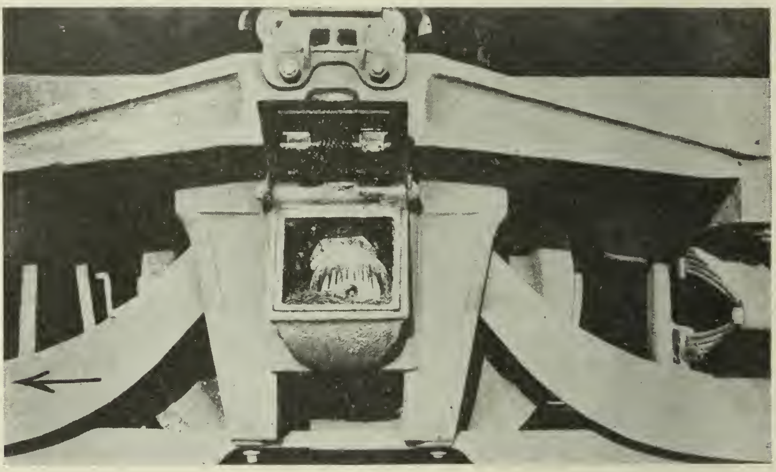


Fig. 2

The results of each test when made were tabulated on a general log kept at the chronograph station. The data secured were carefully checked and rechecked to be sure of eliminating inaccuracies. Numerous curves were plotted, among these being speed time, speed distance and resistance curves. From these curves and from a study of the data obtained certain conclusions were drawn as shown in the following:

1. LENGTH OF STOP WITH STANDARD AND CLASP BRAKE RIGGING

Under like conditions of standing piston travel and brake pipe pressure, the clasp brake cars stopped slightly shorter than the standard brake cars. This difference was in accordance with the higher cylinder pressures obtained on the clasp brake cars as compared with what was obtained on the standard brake cars, resulting from the better efficiency of the clasp brake arrangement in preventing as great an increase in emergency running over service standing piston travel as was obtained with the standard brake arrangement.

When the release springs were removed from the clasp brake cars, the operation of the equipment indicated that entirely satisfactory service would be obtained with release springs of much less strength than those applied to these cars and as far as could be observed, no release springs were needed with clasp brake cars. The stops with release springs removed were approximately 50 ft. (about 6 per cent.) shorter than in tests with the release springs applied, made three days before, but the trials were not carried far enough to prove how much of the difference was due to this change and how much to other causes which resulted in more or less change in stopping distance under equivalent conditions throughout the tests.

2. BRAKING POWER REQUIRED ON CLASP BRAKE CARS TO INSURE PRACTICALLY THE SAME STOP AS PRESENT STANDARD BRAKE RIGGING

The records indicate that with approximately 150% nominal emergency braking power on the clasp brake cars and 170% nominal emergency braking power on the standard brake cars, the difference in running piston travel with the two equipments, (1⅝″ average increase with 150% braking on clasp brake cars and 5″ average increase with a 170% braking power and standard rigging) will be such that the actual per cent. of braking power realized will produce approximately the same stop with each type of rigging.

3. UNIFORMITY OF PERFORMANCE OF STANDARD AND CLASP BRAKE CARS, IN EMERGENCY STOPS

The stops with the three clasp brake cars vary through a considerably narrower range than those for the three standard brake cars with the same percentage of braking power, which indicates that the clasp brake insures a greater uniformity of brake action.

For example, the variation in rate of retardation of the clasp brake cars on different tests under similar conditions amounted to only about 6 per cent., while for the standard brake cars, the corresponding variation is 30 per cent.

The single car emergency tests, made to find out if there was any greater variation in rates of retardation on individual cars with the standard than there was with the clasp brake, indicated that on the basis of the same amount of braking power, the individual cars varied but little and approximately the same amount for both types of rigging (7.65% for the clasp brake and 6% for the standard brake.)

4. Coefficient of Brake Shoe Friction with One Brake Shoe per Wheel and With Two Brake Shoes per Wheel

The results of the tests do not show that any consistently higher average coefficient of brake shoe friction was realized on the cars having two shoes per wheel than on the cars having one shoe per wheel.

5. Wheel Sliding with Clasp and Standard Brake Cars

On the high speed track with the clasp brake cars the longest slide with any of the percentages of braking power used either in emergency or service application was 35 ft. for one pair of wheels. In similar tests with the standard brake cars no sliding occurred in service application but in emergency applications individual pairs of wheels (always middle pairs) slid occasionally. The longest slide recorded was 585 ft. Next in order of length came one each of 330 ft., 125 ft., 100 ft., 90 ft. and several more shorter slides.

6. Effect of Emergency Reservoirs Being Cut in or Out

STANDARD BRAKE CARS.

Comparative tests of standard brake cars with and without emergency reservoirs average 1136 ft. stop from 60 miles per hour with the emergency reservoirs cut out and 970 ft. for the reservoirs cut in. This shows that there was an average increase of about 166 ft. in the length of stop when the emergency reservoirs were cut out.

However, it should be observed in this connection, that there is as great a difference as this between the best and the poorest stops made with the standard brake cars and the emergency reservoirs cut in.

Thus the cutting out of the emergency reservoirs does not necessarily influence the length of stop any more than may result from other causes, such as condition of brake shoes, when all conditions were supposed to be the same.

CLASP BRAKE CARS.

Practically the same relation between the emergency stops with emergency reservoirs in and out was found to exist with the clasp brake cars as indicated above for the standard brake cars. With the emergency reservoirs out, an average stop of 1084 ft. was obtained and with the emergency reservoirs in, the stopping distance averaged 944 ft., or an average increase of 144 ft. when the emergency reservoirs were cut out.

7. TOTAL LEVERAGE RATIO WITH CLASP BRAKE CARS

The average increase in emergency running piston travel over service standing piston travel, averaged from all runs in the log, was 2″ for the clasp brake rigging and 5″ for the standard brake rigging, both at nominally 170% braking power. The maximum increase for the clasp brake cars was 3⅛″ and for the standard brake cars 6½″.

If it is assumed that an increase of 2½″ piston travel is not objectionable, the total leverage ratio on the clasp brake cars can be increased from about 5.6 to 1 (as it averaged for the cars used in these tests) to about 8 to 1, with maximum emergency braking power 150%, should such a leverage ratio be found desirable in order to permit the use of smaller size brake cylinders and still insure satisfactory results.

8. EFFECT OF CLASP AND STANDARD BRAKE RIGGING ON THE MOVEMENT OF THE JOURNALS, SIDE PRESSURE AGAINST PEDESTALS, DISTRIBUTION OF BRAKING FORCES

With the standard brake rigging it was observed that the high pressure exerted by the single shoe on one side of the wheel, tilted the brasses sufficiently to lift one side of the brass a considerable distance away from the journal, so that a wide space was open for waste to be caught between the brass and the journal when the brake was released. One instance was observed when on a service application of the brake, waste was found wrapped around the journal. The collar was forced nearly and in some cases quite to the side of the box and in all cases the boxes were forced tightly against the pedestals. See Figs. 1 and 2.

These effects were not confined to emergency applications but were also noted in service applications of the brake and are all in the direction of producing hot boxes and rough riding during brake applications. The binding of the boxes against the pedestals and the unequal distribution of the percentages of braking power with the single brake shoe per wheel, also tend to produce slid flat wheels.

With the clasp brake arrangement none of the effects just mentioned existed.

9. Service Applications with Standard and Clasp Brake Rigging

While the records show but a slight difference in length of stop in service applications in favor of the clasp type of brake rigging, there was a marked improvement in the riding of the cars during service stops with the clasp brake cars as compared with those of the standard brake cars, with less displacement of trucks, journals, etc.

10. Relative Wear of Brake Shoes with Standard and Clasp Brake Rigging

While there was no record of the amount of brake shoe wear by weighing the shoes, it was observed that the shoes wore down much faster with the standard brake rigging than with the clasp brake rigging. While used shoes were applied to all cars at the beginning of the test, some of the shoes on the clasp brake cars had not been worn down to a full bearing at the conclusion of the tests. The shoes on the standard brake cars wore down to a bearing in a few days, but in some cases did not hold this bearing but warped away from the wheel so that the amount of surface in contact was changing from day to day.

11. RELATIVE HEATING OF WHEELS AND SHOES WITH CLASP AND STANDING BRAKE RIGGING

It was noted that the temperature of both wheels and brake shoes with clasp brake cars was uniformly much lower than with the standard brake rigging, which would reduce to a minimum the heating of tires and damage to wheels and prolong the life of the brake shoe.

The tests discussed briefly above brought out conclusively that the clasp brake was the proper design of brake for use on heavy passenger equipment. The increasing tendency toward all steel cars has made necessary a design of brake which will be sufficient to give a stopping distance in both service and emergency equal or better than that obtained with the standard brake and do this without sliding wheels. The fact that practically all new passenger cars purchased on the N. Y. C. Railroad have the clasp brake and that little or no trouble is experienced with slid flats must be considered as favorable to the new design.

A NEW SOLUTION FOR THE PROBLEM OF SELECTIVITY IN TORPEDO CONTROL

By B. F. Miessner, E. E., '17

The recent War Department tests of the Hammond Wirelessly directed torpedo, which has been reported from many authoritative sources as the most formidable weapon of destruction ever developed for naval warfare and the many newspaper accounts and editorial comments occasioned by the remarkable success achieved in these tests, makes a discussion of the solution of one of the chief problems encountered particularly interesting at this time.

A practical, shore-directed torpedo has, for years, been one of the wildest dreams of Naval and Army officers. Given a high speed, semi-submerged vessel, carrying a sufficient charge of high explosive material to blow the biggest dreadnaught virtually into pieces, and a reliable and accurate means of guiding it from a distance. With these a nation need never fear invasion by sea. A large number of these torpedoes (a thousand of which could be built for the cost of a single battleship) scattered along the coast with wireless control stations for operating them would, indeed, afford a most effective means of coast defense.

The realization of these facts as long as twenty years ago led inventors and scientific men to focus their attention on the development of a dependable means of distant control for self propelled boats. Now, at the end of two decades of work by investigators in all quarters of the globe twenty years of endeavor, failure, and minor successes—we are at last upon the threshold of a new era in Naval warfare, an era fraught with possibilities, the perception of which even by the veriest layman, requires no over-exercise of the imagination. An era of WARFARE we say, and yet can we help but say of PEACE as well, for is it not true that every engine of destruction conceived by man is also a weapon of construction? Does not every death dealing instrument of war tend to avert the very end for which it was created? Does not every new advance in the science of human slaughter make war more and more horrible and humanity less and less tolerant of these relics of barbarism, these present-day methods of settling international difficulties, which even now are exacting their tremendous revenue of human life and misery?

Considered broadly the two greatest difficulties to be overcome in the evolution of a serviceable dirigible torpedo, have been,

1. The lack of a reliable means of transmitting and receiving a sufficient amount of energy to actuate the control apparatus at useful distances.

2. "The Selectivity" problem. This, stated simply, is to provide a means of allowing the shore station to direct its torpedo unhindered by the attempts of the hostile battleships to interfere.

The first of these difficulties has only been surmounted within the last three years; the second, though not yet completely solved, is well on the way and bids fair to make complete the realization of the invention's possibilities. The fact that Mr. Hammond has successfully controlled a high speed, explosive-laden boat at distances up to thirty miles from the transmitting station while deliberate attempts to interfere were being made by nearby wireless stations, furnishes proof enough to convince the most skeptical, of the invention's value in defending the extended coast lines of the United States.

The selectivity problem, which is the greatest by far of all obstacles to be overcome in the successful evolution of a wirelessly controlled torpedo is one of comparative difficulty depending upon the degree of non-interferability desired.

A selective receiver may be likened to a safety vault. The transmitter corresponds to the owner of the safe and he alone possesses the combination. No safes are absolutely burglar-proof, and their value depends principally upon the length of time required for a skilled cracksman to reach the inside. Likewise no receivers are absolutely selective for the simple reason that an operator of another station bent on interfering can take observations and measurements on the signals sent out to the selective receiver (just as a burglar may watch the opening of a safe by the owner) and adjust his own apparatus to emit waves of exactly the same characteristics as those of the transmitter designed and adjusted for the selective receivers operation.

The burglar, instead of trying to learn the combination of a safe, may use sheer force in reaching the inside; an explosion of nitro-glycerin for example. In the same manner a hostile transmitting station can perform the desired effect in the selective receiver, i. e., operate the receiving relay, by the emission of very strong signals, so that forced oscillations are set up. This is known as the "whip crack" effect and it is believed that very few receivers are immune from it.

The best wireless signalling sets, such as those used by the United States Navy, are considered very selective and yet the interference existent between them is quite serious. Take for example: Washington is receiving a message from the Eiffel Tower Station in Paris which is sending at 3,000 meters wave length. It is easily possible for a station in California with an equal amount of power and at practically the same distance to make the Paris message unintelligible at Washington simply by sending signals at or within, say, two or three per cent. of 3,000 meters wave length.

Again, some insignificant station, with little power and within a few miles of Washington, could make it practically impossible for Washington to receive any messages at all from distant stations, by sending out broadly tuned signals of high damping. These highly damped, or untuned signals, by the previously mentioned whip crack effect, cause the receiving antennae to vibrate in their own periods regardless of what these periods may be and thereby produce a great deal of interference. To illustrate: sing a clear, steady tone into a piano. The string, which when struck, emits that tone will audibly vibrate in resonance. Then shout loud and gruffly into the same piano; practically every string will be set in vibration thus producing a dull roar. The first tone corresponds to the signals sent out by tuned transmitters; the second (noise) to the whip crack signals emitted by an untuned transmitter.

Another comparison might serve to illustrate, the degree of selectivity necessary for torpedo control. We have three persons, A, B, and C. A and B are together at one place and C is a mile away. The problem is to allow A to hear what C says while B is shouting in his ears. "Impossible," you say? Yet the torpedo problem is practically an exact analogy. We must be able to make the electro magnetic ear of the torpedo hear our control impulses eight miles away, while it is at the very side of a battleship capable of almost deafening it with a force of its own powerful signals.

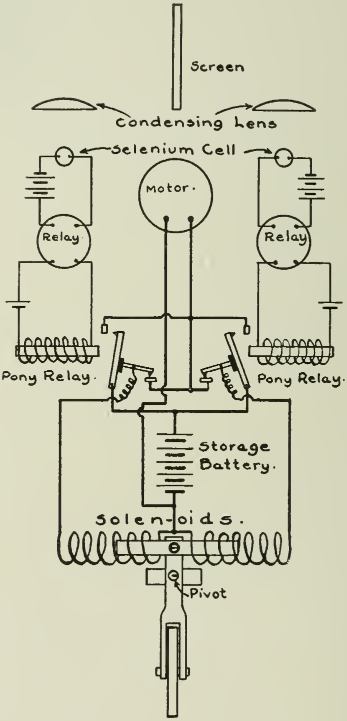
It is true we could sidetrack the selectivity problem and simply use such a large amount of energy at our shore station that more energy could be delivered to the torpedo at eight miles distance than the hostile battleship could deliver to it at a hundred feet. This is possible because the amount of energy that can effectively be used aboard a modern battleship does not greatly exceed five K. W. This is due to the limited size of the antenna. A shore station, with practically no limits on the size and height of its antenna, can easily use 100 K. W. The shore station also has the additional advantage of being able to direct its energy somewhat in the general direction of operations. This can be accomplished either by the use of an inverted "L" type antenna with a flat top, long, in proportion to its height, as suggested by Marconi, or by the use of the Bellini-Tosi Radio Goniometer.

Side stepping the problem, by using a land station of tremendous power is, however, not the practical and efficient solution. In the first place although desirable, absolute selectivity is not necessary. A receiver that would require, say, fifteen minutes time for the enemy to learn its combination, that is, the characteristics of its operative wave, would in all probability satisfy the requirements. In that length of time the torpedo would very likely have completed its work of destruction.

Since the problem of securing a sufficiently high degree of selectivity to insure non-interferability has been attacked from many different sides, without the desired results. Those engaged in this work have cast about for paths which might lead to the solution of the real problem. This, after all is not one of selectivity, although heretofore looked upon as such but it is simply one of preventing interference. A safe manufacturer, instead of devoting his entire attention to developing complicated combination locks or explosion-proof vaults, might arrive at the same desired end, namely to keep burglars out by an entirely different route. This might be accomplished by electrifying the safe with powerful apparatus within it so that the burglar would not dare to tamper with it for fear of being his own executioner.

The problem of selectivity likewise can be cast aside as one of secondary importance and the real problem of keeping the enemy from tampering with the torpedo by means of their own wireless transmitter, solved by the use of apparatus which will make them their own executioner.

In 1912 the writer, associated with John Hays Hammond, Jr., developed an apparatus which we have called "An Orientation Mechanism." The principle involved in this machine has been applied to torpedo control with this same idea of making it hazardous for the enemy to attempt interference. This orientation mechanism which has also been popularly called the "Electric Dog," in its present form, consists of a rectangular box about three feet long, one and a half feet wide, and one foot high. This box contains all the instruments and mechanism, and is mounted on three wheels, two of which are geared to a driving motor, and the third, on the rear end, is so mounted that its bearings can be turned by electro magnets in a horizontal plane. Two five inch condensing lenses on the forward end appear very much like large eyes.



Wiring Diagram – Electric Dog

Fig. 1

If a portable electric light be turned on in front of the machine it will immediately begin to move toward the light, and moreover, will follow that light all around the room in many complex manoeuvers at a speed of about three feet per second. The smallest circle in which it will turn is of about ten feet diameter this is due to the limiting motion of the steering wheel.

Upon shading or switching off the light the dog can be stopped immediately but it will resume its course behind the moving light so long as the light reaches the condensing lenses in sufficient intensity. Indeed, it is more faithful in this respect than the proverbial ass behind the bucket of oats. To the uninitiated, the performance of the pseudo dog is very uncanny.

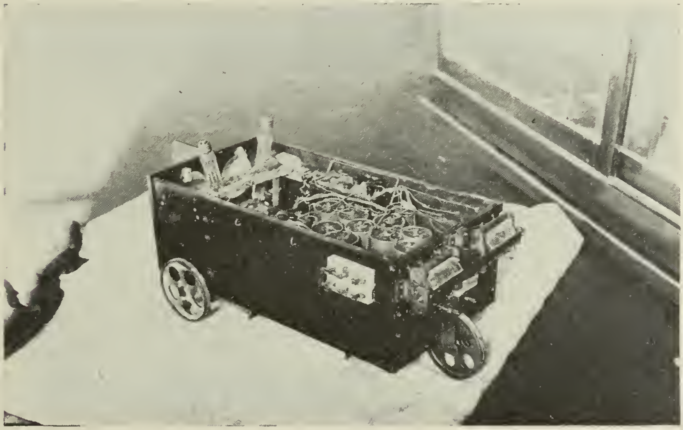


Fig. 2

The explanation is very similar to that given by Jaques Loeb, the biologist, of reasons responsible for the flight of moths into a flame. According to Mr. Loeb's conclusion, which is based on his researches, the moth possesses two minute cells, one on each side of the body. These cells are sensitive to light, and when one alone is illuminated a sensation similar to our sensation of pain is experienced by the moth; when both are equally illuminated, no unpleasant sensation is felt. The insect therefore keeps its body in such a position, by some manner of reflex action, as will insure no pains, and in this position the forward flying motion will carry it directly toward the source of light.

The orientation mechanism possesses two Selenium cells, corresponding to the two light sensitive organs of the moth, which, when influenced by light effect the control of sensitive relays, instead of controlling nervous apparatus for pain production, as is done in the moth. The two relays controlled by the selenium cells in turn control electro magnetic switches which effect the following operations; when one cell or both are illuminated the current is switched onto the driving motor; when one cell alone is illuminated, an electro magnet is energized and effects the turning of the rear steering wheel. The resultant turning of the machine will be such as to bring the shaded cell into the light. As soon and as long as both cells are equally illuminated in sufficient intensity, the machine moves in a straight line toward the light source. By throwing a switch, which reverses the driving motors connecting, the machine can be made to back away from the light in a most surprising manner. When the intensity of the illumination is so decreased by the increasing distance from the light source, that the resistances of the cells approach their dark resistances, the sensitive relays break their respective circuits, and the machine stops.

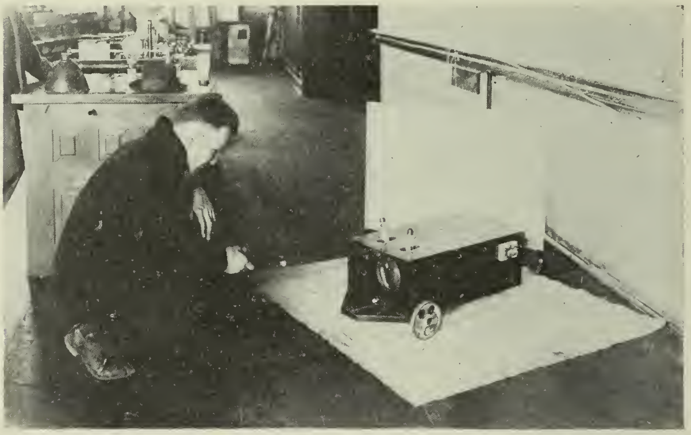


Fig. 3

The principle of this orientation mechanism has been applied to the Hammond Dirigible Torpedo for demonstrating what is known as Attraction by interference. That is, if the enemy tries to interfere with the guiding station's control, the torpedo will be attracted to it. The torpedo is fitted with apparatus similar to that of the electric dog, so that if the enemy turns their search light on it, it will immediately be guided toward that enemy automatically.

In order that the search light used by the control operator may not have this same effect, use is made of a Gyroscope to keep the turn table upon which the cells are mounted, in a fixed position relative to the earth. In this way no matter how much the torpedo turns, or in what direction it is traveling the selenium cells will always face from the shore and toward the attacking battleship in the open sea.

By means of two directive antennae, instead of two selenium cells the same principle may be applied for attraction by interference when Hertzian, instead of light waves are used. Sound waves might also be utilized in a similar manner so that the sound reaching the torpedo (which would be equipped with two submerged microphones made sensitive and directive by megaphone attachments) from the pounding of the battleships engines and other machinery, would effect its attraction in a way analogous to the attraction of a source of light for the orientation mechanism. It is just possible too, that similar apparatus could be used for the detection of submarines, or for defense against them.

PROGRESS IN METHODS OF WATER PURIFICATION

By C. A. Jennings, Purdue, '06

Although alum was used in Egypt many years ago to clarify water, nevertheless very little was done toward purifying water until the last century. The underground sources of water supply were usually sufficient to furnish all the water needed. As cities grew in size, it became necessary in many cases to find sources of water supply more ample for the present and future needs. Many cities began to use surface water supplies. Incident to the growth in population and the introduction of sewer systems was the increased pollution of the surface water supplies. The new science of bacteriology, developed about the middle of the last century, showed the relationship between polluted water supplies and intestinal diseases. Means were adopted to purify as well as clarify water. Storage reservoirs, settling basins and filters then came into use. For various reasons the installation of filters (slow sand and rapid sand or mechanical) was more widely adopted than other methods of purification. Principally this was due to their adaptability to almost any topography, capability of handling water of any character and their compactness. The rapid and phenomenal growth of filtration in the United States is shown in the following table compiled by Mr. Geo. A. Johnson of New York. This table shows the population supplied with filtered water:

1870	None
1880	30,000
1890	310,000
1900	1,860,000
1910	10,806,000
1914	17,291,000

Filter plants were formerly installed with a guarantee to remove all but 2% or 3% of the bacteria in the water. As the population per square mile on the watersheds became greater and greater and the volume of sewage discharged into the streams became larger and larger, the burden placed upon the purification plants was found to be excessive. This condition called for the development of a finishing process.

About 1908 four methods of treatment supplementary to filtration and other water purification systems were developed. They were the hypochlorite, liquid chlorine, ozone and ultra-violet-ray processes. Chlorine gas, a by-product of the manufacture of soda, when passed into lead lined chambers containing dry, slaked lime, forms bleaching powder, hypochlorite of lime or "hypo" as it is called by waterworks men. The average strength of hypo, expressed as "available chlorine" is about 37%. Hypo was first used on a large scale in water work in 1908 at the Bubbly Creek filter plant at the Chicago Stock Yards. It was not used for clarifying water but for oxidizing the organic matter and killing the bacteria. It was found that this treatment seemed to have an affinity for the disease producing bacteria in water, which was the primary object of such supplementary processes. Up to 1914 some 500 cities had adopted this treatment, some using it alone as an emergency treatment while other cities used it as an adjunct or finishing process with filtration, sedimentation or storage. It has served its purpose well. Many epidemics of Typhoid Fever have been arrested and probably many more have been averted by the use of this process. It has been a cheap treatment to install and to operate and its efficiency cannot be questioned.

Within the last year or 18 months a new treatment has reached a practical working basis and has been rapidly replacing hypo treatment. This is the liquid Chlorine method of water disinfection. Chlorine gas is pumped into steel cylinders and liquified by pressure. When so prepared the gaseous or liquid chlorine will analyze 99% or more of "available chlorine." Cylinders are connected to special reducing valves and gauges and the chlorine is fed to the water under treatment usually in the form of a solution prepared by discharging the gas (the liquid chlorine becomes gaseous chlorine as it passes from the higher to the lower pressure) into an absorption tower. This is filled with some substance which will not be attacked by the chlorine and will present considerable surface for absorption of the chlorine by a stream of water which flows down through the absorption tower.

Liquid chlorine treatment is replacing hypo because usually it is cheaper, it is more efficient, its regulation and adjustment can be more easily and quickly accomplished than with hypo, the reaction is more rapid and less affected by low temperatures of water and there is less opportunity for tastes and odors resulting from liquid chlorine than from hypo treatment. In short, it seems to possess all of the advantages and only a few of the disadvantages of hypo treatment. Philadelphia, Brooklyn, Wilmington, Niagara Falls, Oklahoma City and a large number of other cities have already adopted this newly developed and newly perfected method of water disinfection. The Bubbly Creek filter plant at Chicago, the first to use hypo, has recently discarded hypo in favor of liquid chlorine.

Ozone is a gas. It is represented by the symbol O_3, that is, it is a molecule of Oxygen to which is attached an extra atom of Oxygen, which however, is only loosely held. Ozone is produced by electrical discharges through the atmosphere. To obtain the best results, the water must first be freed of suspended matter, preferably by filtration. Ozone is an oxidizing agent as are also hypo and liquid chlorine. It is more expensive to install and to operate than either of these and up to the present time, has not been reduced to a practical working basis in this country although it is said that there are several plants in successful operation in Europe.

Ultra-violet ray disinfection is accomplished by exposing water to the action of the ultra-violet rays produced by specially constructed lamps immersed in the water to be treated. These rays are strongly germicidal. However, the penetrating powers of these rays are limited so that it is absolutely necessary that the water be free from suspended matter and have a color not exceeding 15 to 20 parts per million. It is therefore evident that in order to produce reliable results, the water must first be filtered. As with ozone, this treatment is somewhat expensive to install and to operate, compared with hypo and liquid chlorine. Likewise, it has not been placed on a practical working basis in this country, although as claimed for ozone, there are numerous successful operating plants in Europe.

Thus it is seen that when the work to be done by filtration and other water purification processes became unduly heavy and the results at times questionable and unreliable, finishing processes were developed to relieve this extra task and so ensure reliable results at all times. Although all Typhoid Fever is not caused by polluted water, nevertheless most of the cases are caused by water. One of the best evidences of the efficiency of these finishing processes is the continued annual reduction in the Typhoid Fever death rates of the cities using such processes.

RECENT CONTROL REQUIREMENTS FOR ELECTRIC VEHICLES

By W. H. Holder, E. E., '05

The manner of providing for the speed control of the motor in electric vehicles is of vital importance to the car driver that he may have quick and dependable response; to the passengers, that the acceleration may be smooth; and to the one who pays for maintenance that the outfit may be efficient. The life of the controller contacts and the absence of trappy construction enter into the problem of speed control. Mileage is also increased by the elimination of I^2R losses in the controller and in the series resistances which may form a part of it.

Practically all of the motors used at present on electric vehicles are of the series type with the series field winding in two sections. The battery on the car may either be provided, permanently connected up as one group of cells, or it may be divided into two equal groups.

For the simpler type of speed control an extensively used drum type construction has been designed which gives speeds as follows:

Single Voltage Control

1st. Field sections connected in series—two sections of series resistance.
2nd. Field sections connected in series—one section of series resistance.
3rd. Field sections connected in series—no resistance in circuit.
4th. Field sections connected in parallel—shunting resistance across fields.

With this controller the shunting resistance, which is used for weakening the field, takes very little energy and its use for moderate speed increase is considered good practice. However, considerable energy is wasted in the I^2R heat developed in the series resistance which is used on the first two running speeds; since the driver will necessarily run for a considerable portion of the time on one or the other of these low speeds.

The demand for better efficiency, longer mileage and the elimination of series resistances has brought forth another type of controller which is usually built in drum form as follows:

DOUBLE VOLTAGE CONTROL

1st. Battery sections connected in parallel—field sections in series.

2nd. Battery sections connected in parallel—field sections in parallel.

3rd. Battery sections connected in series—field sections in series.

4th. Battery sections connected in series—field sections in parallel.

With the above combination of circuits it will be noted that each one forms an efficient running point; there being no loss due to resistance and at the same time an equally wide range of speed control is obtained. The absence of resistance increases the mileage appreciably and allows maximum torque to be obtained on first point.

One of the chief advantages of this double voltage scheme of control is in the elimination of series resistance, used with the single voltage controllers, which gives the driver a great deal of trouble. This resistance burns out with annoying regularity when the operator runs the car for several miles on the low speeds. It might be thought that resistance of sufficient capacity for all emergencies could be used but if this be designed it will be found that the excessive weight and bulk make is absolutely prohibitive on pleasure cars at least, and therefore it is very frequently found that this resistance burns out, getting red hot or even in some cases setting the car on fire. With the double voltage control system one can operate on the lowest speed for any length of time, not only without troubles from burnouts but he is running under efficient conditions. The resistance used with single voltage control is designed for intermittent duty and is intended primarily for acceleration speeds and not for continuous running.

Tests made on the same car under the same conditions of road, stops and speeds, total length of run being approximately 55 miles in each case and stops being made uniformly five times per mile resulted in the following data:

Average watt hours per car mile with single voltage control—244
Average watt hours per car mile with double voltage control—208

of 17.3 percent more energy consumed by the single voltage control for the same amount of work done. For these reasons it is becoming very frequent to install double voltage control where possible.

In commutating battery connections, that is, in changing from sections in parallel to the sections connected in series, many control schemes allow the power circuit to be broken. With this type of controller if the operator does not throw the control lever from the running point where batteries are in parallel very accurately to the next point, where the batteries are connected in series, the power circuit will be opened giving an unpleasant sensation and often causing some embarrassment to the operator. In the down town traffic where automobiles are being hustled across the street by the traffic man, cars have been seen with this type of control, in which the lady operator started her car and pushed the control lever hesitatingly to the point where the power supply was cut off and her car stopped, but at the wave of the policeman the lever was inched further and the car would suddenly shoot forward necessitating a great deal of skill to prevent an accident. This excess starting current is also abusive to battery and motor.

To overcome this trouble recourse is taken to some sort of transition resistance to prevent short circuiting of the batteries while they are being commutated without cutting off the power. It might be stated that as to the necessity of a battery transition resistance, there has been developed by one concern at least, a sufficiently accurate star-wheel or notching device which really prevents the operator from pausing between points. This at least is the claim, but it is the writers' opinion that a star-wheel device of sufficiently pronounced notching to obtain this result would be entirely too tiresome to operate. The ordinary control lever, particularly for ladies' use, should have a star-wheel effect only sufficient to guide one to running points and not one strong enough to actually throw the control lever from the dead center when operating it.

The transition resistance can be worked out quite easily on the drum; the principle being to connect a resistance in shunt with the two sections of the battery while they are in parallel, then open the parallel connections for the batteries (not disconnecting from motor) leaving the two sections and the resistance in series, and afterward shorting out the transition resistance.

Similarly the circuit should not be broken when changing from field sections in series to field sections in parallel. Transition resistances of the same nature are frequently used for this purpose, but since it is possible to short circuit a section of the series field without damage, there is a preferable scheme which is worked out as follows. Have the two sections in series; first short out one of the field sections which leaves the remaining one active, then open the circuit of the section which is shorted out (without opening the line supply to the active section), then connect this first section so that it will be in parallel with the active one.

It has been found that further sub-division of the battery groups to obtain an additional number of speeds is not practical, on account of the complication of the controller and the additional wiring required between controller and battery. These items increase the cost of production—the extra leads introduce a fixed I^2R loss and further, the speeds obtainable with but two groups give smooth acceleration and (for the average maximum speed of 20 miles per hour) sufficient speed points.

As a further development of this same scheme of double voltage control there has been developed a full magnetic type of control which consists of a series of magnetically operated contactors. These switches are controlled from a small master controller which is mounted directly on the steering lever and is so small that it may be enclosed by the hand. The advantages of this magnetic scheme are in general; that it is nicer to operate, particularly for a lady; instead of having two levers to operate there is but one, the steering lever; the master controller having an entirely different motion and is therefore not as likely to be confused with the steering lever. A quick snappy action of the contactors equipped with magnetic blow-outs, reduces the arcing and deterioration of contacts to a minimum. It is easier to operate this small master than to drive a drum controller through all of the bell cranks and against the star-wheel action, with which most cars are equipped and even the battery transition resistance may be eliminated since the batteries may be changed from parallel to series connections by the operation of a single magnetic switch which operates so quickly that the momentary opening of the power circuit cannot be noticed by the operator.

In combination with the hand master controller a foot operated master may also be used; the preferable arrangement being to use the hand master primarily as a speed setting device and to connect the foot master so that when the foot is removed from it the car will accelerate up to the speed as determined by the setting of the hand master only, but the speed may be lowered by pushing the foot master and the car stopped when it is fully depressed. This scheme is very desirable in crowded traffic for quick and frequent stops and starts.

In addition to the regular functions of acceleration, speed control and reversing obtained with the full magnetic controller and its master, provision may be made for dynamic braking. A push button is added to the master which operates to close a contactor connecting a resistance in series with the motor armature and the fields after power is cut off so that if the car speed is about six miles per hour or higher a current is generated by the motor thus producing an electrical braking. This is used regularly as a service brake instead of the foot brake and a mechanical foot brake is used only for an emergency quick stop. A magnetically operated disc brake is also used by some manufacturers; this being operated also by closing its electrical circuit in the master controller. This may be used to serve the same purpose as the dynamic braking.

The character of the dynamic braking when applied is to give a peak at the start, followed by a rapidly decreasing retarding effect as the speed lowers owing to the lower electromotive force developed in the armature, whereas with the magnetic disc brake the braking effort is least at the initial application, increasing as the speed decreases on account of the increasing coefficient of friction at lower speeds.

In one make of car both types of electrically controlled braking is used. The dynamic is first applied and if not sufficient (on account of low speed) the magnetic disc brake is also used. The combination of the two applied simultaneously when properly designed gives an ideal retarding effect of practically uniform value from high to low speed; the weakening of the dynamic braking at lower speeds being equalized to a considerable extent by the increasing value of the disc brake effect.

A FEW NOTES ON SAFETY FIRST

By John D. Ong, Ch., '13

Engaged in Accident Prevention Work,
with The National Malleable Castings Co., Chicago.

The Safety First movement has grown so remarkably fast and vigorously within the last three years, that it would be folly to attempt to touch all sides of the subject in an article of this length. The writer will mention only a few general points bearing on accident prevention and then cite some of the measures adopted by one company in its safety first work.

Almost all large industrial establishments have taken up the movement and the smaller ones are following. The result is that serious and fatal accidents, and occupational diseases are now almost unknown in some lines of work, where such occurrences were common only a few years ago. Other plants have materially reduced the number of serious and fatal accidents. This reduction in the number of injuries has been brought about by: first, co-operation of the men "higher up" with the Safety First movement; second, education of the employees regarding safety; third, safeguarding machines as well as the workmen.

Men as a rule resent being driven. Even the uneducated, foreign laborer doesn't enjoy it. The probabilities are that if a man is ordered to take a precaution, the reason for which he doesn't understand, he will do it but he will not feel right about it. The first chance he gets or as soon as he thinks the "boss" isn't looking, he will do it his way and disregard the precaution altogether. Especially is this true when Safety First work is being started. The man in charge must be thoroughly in sympathy with the movement. He must understand how to handle men and be able, by what he says and how he acts, to gain the good will and confidence of the men. It is the employer's duty to bring the employee to see that the chief reason for installing safety methods, is for his, the employee's advantage. This is one kind of work employees cannot be driven into—they must be led. For example, a foreman cannot give his men goggles and say: "Wear these during working hours," and expect the men to wear them without complaint if he works around without wearing them himself. The men will find a dozen objectionable features in a very short time. The foreman must practice as he preaches and take the same precautions he asks the men to take.

Very closely connected to the co-operation of the men-in-charge of the Safety First work, is that of the education of the workmen. Again, using the example cited above, if the foreman wears the goggles for a week before asking the men and explains why they are asked to wear goggles, pointing out the danger and risks taken by not protecting their eyes, then he will get satisfactory results. The men are skeptical at first as to the motive of the company and as to the advantage of wearing goggles. They should not be pushed into it too hurriedly. Employees should be taught to recognize the danger and risk they take of working unprotected; of working with unprotected machines; of working with careless men, who do not do their work in a safe way; of being careless themselves; of ignoring signs, bulletins and suggestions of safety offered by the company. They must be educated to think, feel and live "Safety First."

If the men are not moved by the proper spirit, all the safeguards on machines and all the protectors given the men will not materially reduce the number of accidents. If the workman doesn't like the guard provided, he will do his utmost to show up the disadvantages and weak points of that guard. It is not so much a question of making machines "foolproof," as it is to prevent the men from taking chances. The education of the workman is, in the writer's opinion, the most important thing of all in accident prevention work.

Different plants inaugurate and carry on their safety work along several different lines; one company believes it can best attain results by placing it in the hands of a committee of workmen; another will have a workmen's committee meet and discuss the work with some of the men in charge of the plant; another will depend on the superintendent, foremen and bosses to carry on the movement. Some companies offer prizes to the workmen who submit practical safeguards or safer methods for doing a certain piece of work; other concerns object to giving prizes or money for suggestions, and many plants rely on the men to obey the notices, warnings and bulletins which appear from time to time on the bulletin boards in the yards and buildings. Each method has its good points and it is very much a matter of local conditions which will be the most effective in any one plant.

To give an idea of what The National Malleable Castings Company is doing for its men, a few of the precautions taken to prevent accidents will be indicated. Proceeding on the belief that a disabled or unhealthy employee is dangerous to his healthy and physically able fellow worker, all men are given a physical examination on entering the employ of the company. It is determined if the applicant's sight, hearing and heart action are good, if he has any physical deformities, such as flat foot, hernia, missing fingers, impaired use of either hands or legs, old sores or wounds. The company does not expect perfect men, but it does want sound men. The applicant is questioned concerning his knowledge of the work he is to do, especially what his course of action would be in case of accident. The employee is urgently requested to report to the doctor's office every time he meets with an accident, no matter how slight the scratch or how trivial the cut or burn. Failure to report the accident may be sufficient cause for laying off or discharging the employee.

All goggles, hand leathers, leggings and knuckle guards mentioned later in this article are sold to the men at cost price, are repaired, replaced or improved free of charge. When the man leaves the employ of the company he is refunded the original cost of them. Molder's shoes are sold at cost, but are not repaired or replaced.

If the new man be a molder, he is fitted with a pair of light goggles, a canvas legging, which protects the leg nearest the hand ladle when pouring-off, and a pair of molder's shoes, for no lace or button shoes are permitted on account of the danger of melted iron lodging in the shoe lacing with the resultant burns. The legging extends from a few inches above the knee to the ankle, covering the top of the shoe, so that there is no place for iron to lodge. All men working around melting furnaces at pouring-off time are required to wear goggles, for it was formerly found that there were frequent eye injuries due to spattering when the melted iron struck a "green" ladle, or wet mold weight. A foundry laborer, who shakes out molds, shifts mold weights and handles pig iron and sprue, is provided with hand leathers. These are a sort of crude leather glove especially designed to protect the ends of the fingers, and prevent hot sand from burning the wrist. Wheelers and truckers are provided with handleathers and goggles. Outside of the foundry all workmen must wear goggles during working hours. Molders and molders' helpers are required to wear goggles only while pouring-off. As in the case of not reporting accidents, failure to wear goggles may mean suspension of the employee.

Men in the trimming room, who handle only the smaller castings are provided with knuckle guards of leather. Trimming room men as well as those working in the straightening and fitting departments are provided with goggles having a light, fine-mesh wire gauze at the sides of the lenses, to prevent chips from striking the eyes from the sides. Grinders who must work close together are also fitted with this style of goggle. Workmen in the annealing, rolling, slag and sprue, machine, carpenter and pattern departments are fitted with a light weight plain goggle similar to the style used in the foundry. Employees in the machine, carpenter and pattern shops are required to wear their goggles only on certain kinds of work.

Eye injuries have been reduced from an average of 20 to 2 or 3 a month. Where formerly there were many serious eye accidents, the present ones are only minor eye injuries. When the $^9/_{64}$-inch thick lens of the chippers' and trimmers' goggles are broken by a chip or test lug, and the eye is found to be uninjured, the advantage of wearing goggles will be recognized.

Belts, which are in any way close to or which are liable to be brushed into by workmen, are guarded. Gears are covered wherever there is a possibility of an employee getting a finger caught. Irregular lathe chucks are covered. Emery wheels are covered almost entirely by an iron guard and where the nature of the work permits, a small glass guard is placed between the operator's face and the work, allowing the man to see his work, but which prevents sparks from flying into his face and eyes. Two emery wheels are mounted on each machine and a canvas guard between the two wheels prevents the sparks of one wheel from striking the workman at the adjacent wheel. Where two machines are close together, a canvas guard is placed between machines. The eye accidents in the grinding department have dropped about 90 per cent. since the installation of these guards and wearing of goggles by the men.

Drop hammers, air hoists, chain tackles, traveling cranes and elevators are inspected daily, to make sure that they are in a safe working condition. Drop hammers are provided with a safety device which prevents hammer from dropping if hammer release is accidentally tripped. Wheelbarrow handles are equipped with knuckle guards, which prevent injury to workmen's hands while passing through swinging doors or along passageways. Chisels of all kinds are inspected regularly for "mushroomed" heads; if any are found they are ground or taken to the blacksmith shop for reheading. Hammers are inspected to see that the faces are not chipped and under size.

Bulletin boards are placed at the main gates. Bulletins, some of which are furnished by the National Council for Inlustrial Safety, are changed weekly. A pair of broken goggles are generally placed in the bulletin board with a short note attached, stating how the accident occurred and that the goggles probably saved an eye.

Accidents occur even with all the precautions that are being taken, but the attendant in the doctor's office isn't nearly so busy as he was 18 months ago. A practicing physician attends to the more serious cases daily. Doctors' and hospital bills are paid by the company. Of course, it costs quite a little to look after the health of the men, to install and maintain the safeguards on machines and the protectors given to the men, but it most certainly pays. It makes the employee feel that the company is doing what it can to protect him from injury. It gives him a contented feeling and he will do better work, work more earnestly and efficiently if he is provided with a safe place to do his work. When a new man begins his work he doesn't see why it is insisted that he take so many precautions. He is tempted to laugh at and ignore the Safety First policy, but he soon learns that it pays to be on the safe side.

The plants of the National Malleable Castings Company are not the safest ones to work in by far, but they are continually trying to improve and increase the number of safety devices and to remedy dangerous operations. The success in getting the men, mostly foreigners, to participate in this Safety First work, has been due, largely to the way in which the matter has been up to the men, and to the interest which the officials have shown at all times and the personality they have put into it. May the good work go on.

THE CONSTRUCTION OF LOCKS AND DAMS ON THE OHIO RIVER

By F. A. Irick, C. E., '11

With a view to obtaining a navigable depth of nine feet throughout the entire length of the Ohio River, congress, in the river and harbor act, approved June 25, 1910, adopted a project for its complete canalization by a system of locks and dams. The project included the construction of 54 locks and dams at an estimated cost of about $1,180,000 each, and it was required that the work be completed in 12 years.

The boats used on the Ohio River are of light draft and of the usual river type, the packet and tow boats having drafts of from two to six feet. The packet trade in recent years is but a small per cent. of what it was before the day of railroads. This is due largely to the fact that it is possible to depend on a river stage sufficient to transport a boat of even two foot draft but a short time during the year. The greater part of the present traffic is coal and iron products from the Pittsburg district to lower Ohio and Mississippi River and gulf points. The loaded steel and coal boats require for their transportation about a ten foot stage which seldom is maintained but a short time between the months of June and December; and during the winter months, when usually the stage is sufficient for transportation, much of the time the channel is obstructed by ice. When the entire project is completed there will be maintained throughout all seasons of the year a minimum channel depth of nine feet, and transportation will be interrupted only by ice and extreme high water of the winter and spring months.

The Ohio River is 967 miles in length. Originally the proposed system required 54 locks and dams numbered consecutively 1 to 54 from Pittsburg to Cairo, but by some re-locations in the lower river lock and dam number 42 was cut out, leaving a total of 53. The minimum and maximum distances between any two locks and dams is 1.9 miles and 50.4 miles, respectively. In the upper 483 miles of river there are 37 locks and dams and 16 in the lower 483 miles, these varying distances being due to the natural channel differences between the upper and lower parts of the river.

The locks of the entire system are of the same size, 100 feet by 600 feet, and constructed on the same general plan. They are placed so that the land wall is at the foot of the bank nearer the natural river channel. The lift is between 6 and 9 feet in all cases, except lock number 1 which is 3 feet, and lock number 41 in the Louisville and Portland canal which is 28.2 feet, and lock number 54, which is 12 feet. Both the river and land walls of the locks are built of plain concrete, the land wall extending 600 feet above the upper end of the lock and 600 feet below the lower end of the lock to serve as a guide on entering the lock chamber and protecting the channel from the bank erosion. The river wall contains the valves that fill and empty the lock, also on the outside of the river wall at the center of the chamber is built in a small turbine pit in which is installed a turbine that furnishes power to open and close the gates and valves.

The lock gates being used are of the rolling and miter types. Due to the width of the lock and low lift and also a saving in length of the lock walls it was at first thought more economical to use the rolling type, but due to the cost of keeping this type in repair and difficulties of operating when not in perfect condition the miter type is being used in the later designs.

The dams are all of the movable type, that is, they fold down in the bed of the river when the stage is sufficient to give a nine foot channel depth, and do not have any effect on the stage when this condition exists. They extend across the river at right angles to the river wall at the center of the lock chambers in all cases except at the Louisville and Portland canal. The typical dam, in the upper river, is made up of a navigable pass, bear traps, and chanoine weir, in the lower river the bear traps are omitted and where the river is wide a section of fixed weir is added next to the bank opposite the lock chamber. The navigable pass in all cases is between 600 feet and 800 feet in length and is made up of chanoine wickets which in all cases are between the lengths of 12 feet and 18 feet. The elevation of the pass sill is near the elevation of the normal river bed. The standard bear trap is in two sections each 91 feet in length separated by piers, the sill being near the same elevation as the pass sill. They are of the two and three leaf type, the two leaf type being found to give the more satisfactory results. The principle use of the bear traps is to hold the proper head during the raising and lowering of the chanoine wickets, the rises being more gradual in the lower river, their use is found to be unnecessary. The chanoine weir differs only from the navigable pass in that the sill is about 5 feet higher and the wickets correspondingly shorter. The fixed weir is built of plain concrete and corresponds in section to the usual fixed dam.

Where practicable the foundations for the lock walls and dam are laid on solid rock, and where sand, gravel, and earth extend to great depths the foundations are entirely on piles, protected by sheet piles and riprap. Practically all of the masonry work is plain concrete.

The lock gates and valves are operated by compressed air supplied from storage tanks housed in a brick power house on top of the bank near the lock chamber. The compressed air is furnished from the turbine in the pit on the outside of the river wall or from the auxiliary steam plant installed in the power house.

A lock keeper is stationed at each of the completed dams. He has under his charge a force of men sufficient for operating the lock gates, raising and lowering the wickets, maintenance and general repairs. Lockages are made at all times free of charge for any passing boat. The employees are given quarters in permanent houses, 2 to 4 in number, which have been constructed and are maintained by the government for this purpose.

In most cases the construction of a lock and dam is let in one general contract except some of the movable parts and machinery. In some cases contractors have either refused to bid or their bids have been excessive, due to the unreliability of the seasons and character of the foundation material, in which case the government is doing the work by hired labor. The construction season is variable usually being from June to December with occasional freshets which always entail a loss of time and often great losses of material and uncompleted work. The average time of construction is four years.

Beginning at the source of the Ohio 46 miles of the project have been completed, and when all work is done that is now under construction 202 miles will be completed, and when the entire project is completed there will be open to traffic 967 miles of river with a minimum channel depth of 9 feet.

Lock and dams numbers 1, 2, 3, 4, 5, 6, 7, 8, 11, 13, 18, 19, 24, 36, 37 and 41 are constructed, numbers 9, 10, 12, 14, 15, 16, 17, 20, 26, 28, 29, 31, 35, 39, 43 and 48 are under construction and numbers 21, 22, 23, 25, 27, 30, 32, 33, 34, 38, 40, 44, 45, 46, 47, 49, 50, 51, 52, 53, and 54 are to be constructed. Lock number 41 in the Louisville and Portland canal was constructed 80 feet wide; it is at present being widened to 110 feet.

Lock and dams numbers 1 to 10, inclusive, are being constructed from the United States Engineer's office at Pittsburg; numbers 11 to 30, inclusive, from the United States Engineer's office at Wheeling; numbers 31 to 40, inclusive, from the United States Engineer's office at Cincinnati; numbers 41 to 54, inclusive, from the United States Engineer's office at Louisville.

THE FALL CREEK BOULEVARD

By A. A. Smock, C. E., '12

Fall Creek is a tributary of White River into which it flows at a point about one and one-half miles northwest of the center of Indianapolis. It is from one hundred to one hundred and fifty feet wide on an average at low water, although it, of course, widens out at numerous places. Except for a few deep holes in its bed where gravel has been excavated, it is very shallow and has numerous sand bars along its course.

It enters the City of Indianapolis at a point near the northeast city limits and flows southward and westward through the city, for about six miles, approximately half of which is through desirable residence district.

The creek bed has shifted toward the south in the past, and along practically its entire southern side there is a well defined bank varying from ten to twenty feet in height. The northern bank as a rule is quite low and there is a strip of low ground all along this bank that is subject to overflow when the creek rises abnormally, as it does every few years.

The Board of Park Commissioners of the City of Indianapolis have full control of the stream and its banks, and a system of boulevards on both sides of the stream is being worked out. These boulevards are a great benefit in more ways than one. Primarily, they protect the adjacent property, as the roadways are built upon embankments high enough to withstand any flood likely to occur. These embankments are laid out carefully, in long graceful curves and in some places they are two hundred feet from the water line, leaving a space between the driveway and the water for a park. Several sections of the boulevard have been completed for a number of years and they have increased the appearance of the neighborhood very much. They are lined with fine residences, apartments and other high class buildings, which would never have been built along an unsightly creek bank. Other sections of the system have been partly completed by the erection of the embankment and the building of temporary gravel drives, to be replaced later with pavement or macadam surfaces. These sections, offering as they do, a safe protection from high water, have given rise to the building of countless homes upon ground which was formerly left alone because it was low and subject to overflow.

The last two sections of the north drive are now being built. One begins at the Fairgrounds bridge at Thirty-eighth Street and runs southwest to Thirtieth Street. From this point to Northwestern Avenue, about two miles, the drive is complete. From Northwestern Avenue, west to the Big Four Railroad, is a section twenty-six hundred feet long that is being constructed under the writer's supervision.

This section is through a part of the city that has never been considered valuable. The ground for some distance north of the creek is very low and has been used as a dumping ground for many years. The embankment varies in height from five to sixteen feet, and when completed will be from two to four feet above the high water mark of the 1913 flood. The embankment is eighty-five feet wide, with a slope of four or five to one on the stream side, and natural slope on the property side. The four to one slope is composed of whatever soil was obtainable, to provide for future planting of trees and shrubbery.

There are two distinct steps in the construction of the embankment. The first step is the formation of the four to one slope with a top width of about five feet, using all the soil that is on the ground in the lines of the boulevard. The second step is the gradual widening of the top of the fill to its final width of eighty-five feet, using gravel which is taken from the creek bed. The excavation of this gravel thus straightens and deepens the channel of the creek. The design calls for a waterway of about four thousand square feet below the high water mark.

The excavation required to widen and deepen the channel is nearly two hundred thousand yards, about one-half of which is used in the embankment, the remainder becoming the property of the contractor at a stipulated price. As it is nearly all fine sand and gravel, it is washed and prepared for the local street and building work.

Work was commenced in August, 1913, and the four to one slope of soil was completed by January 1, 1914. The remainder of the embankment was complete by May 1st, and since then the entire output of the excavator has gone into the gravel plant. The excavating is done with a Monighan drag-line excavator, a large machine consisting of an upper rotating part mounted on wheels which revolve on an eighteen foot circular track. The base is twenty-four feet square and rests on rollers and heavy planks. The boom is sixty feet long and the bucket is of the Page type scraper bucket, two cubic yards capacity. This machine travels ahead of its work, instead of behind it like a steam shovel does. It was erected at one end of the boulevard and the first thing done was to strip off all the soil it could reach and dump it in the four to one slope on the stream side of the embankment. The excavation was at the average of four or five hundred yards per shift. The machine moved forward thirty to fifty yards per day, according to the height of the fill, leaving behind it an irregular ditch from which the earth was taken and a regular pile of earth in its final place. Then the machine was moved over to the water's edge preparatory to removing a sand bar. This bar was about three hundred feet across and roughly circular. The water flowed around it, making an island of it. The machine was gradually worked down to the water's edge, where it dug for itself enough earth to make a fill wide enough and high enough for it to run upon. Following the machine came a track gang, laying three foot track along the top of the soil previously thrown up, and when the excavator was in position to begin the removal of the sand bar, two dinky locomotives, each with six two-yard cars were used. The bucket on the machine just fills one car, and it was found that two engines could keep the machine busy under ordinary conditions. A train of six cars is filled in about ten minutes as an average, and in the three or four minutes delay while one train gets away and the other one gets in place for loading, the operator of the machine must excavate and throw ahead enough material that the ground men can level up and lay their planking ready for the next forward move of the machine. It is necessary to plan ahead in using these excavators, for they cannot turn in a small space, and considerable difficulty was experienced in working out the manner of the cuts back and forth of this sand bar. One great advantage of this machine is its ability to make its own fill, hence it can go almost any place. On this job it has filled its way across the creek four times, two times when the entire creek was dammed up, and it was necessary to move about thirty feet and then reach out behind and remove the fill to let the water through, using the material thus removed to lengthen the fill ahead.

While removing this sand bar, the dump track was about eighteen hundred feet long, and was continuous except for one switch. The track ran along the top of the embankment and had a switch located so there would be a two per cent.

grade down to the level of the ground at the machine. This machine was then at the extreme end of the work, and as the work progressed it was necessary to take up track, finally when the bar was entirely removed the excavator moved along the bank of the creek, cleaning up behind itself and leaving a comparatively smooth bank which required only a little hand trimming.

At one point in the work was the double outlet of two concrete storm sewers. This was an unsightly structure. On account of the low grade of the sewers and the surrounding territory, the flow lines were only a foot or so above low water, and the tops projected out of ground nearly ten feet. It was decided to submerge the outlets of these sewers and the excavator was used to remove about fifty feet of the concrete. The scraper bucket was taken off and a fifteen hundred pound drop hammer put on to break up the concrete. The immense power of the engines was very useful in handling the broken concrete. After the sewers were demolished, the bucket was put back, the machine reached out behind itself, dug enough dirt to fill in the holes where the sewers had been, and passed on.

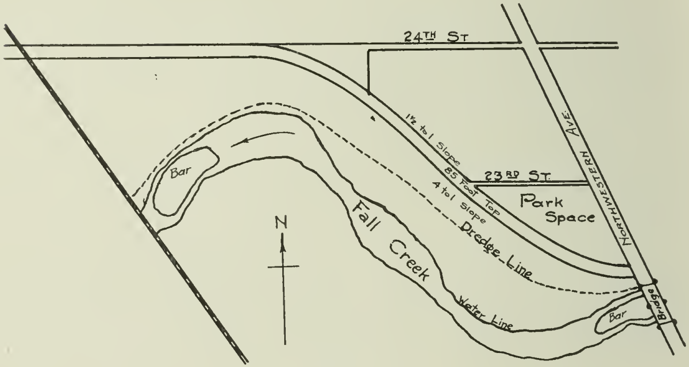


Fig. 1

From this point for the remaining twelve or fifteen hundred feet, the boulevard was from one to three hundred feet from the bed of the stream, and all the intervening material was to be removed, in order to widen the creek. It was deemed advisable to also clean up the part of the channel where the water was running, at an average depth of about three feet. The width of the water was about one hundred feet, so it was necessary to work the machine out into the creek forty feet, so the bucket could reach to the further side of the stream. The dump track was relaid and the switch placed at the east end on top, from which the track ran west down a one and one-half per cent. grade for eight hundred feet, where another switch was placed, the track again running east to the machine, which was about two feet above the water level. The track was floated, that is, temporary, and moved daily, to keep it always the proper distance from the machine, which was steadily moving upstream, making its own fill and cleaning up the channel to the side and rear for a total width of about one hundred feet. After moving forward about eight hundred feet, it was again necessary to cross the creek to clean out a sand bar, after which the machine came back on a second cut through. A third cut will be required to finish the work.

The operation of the work is carried on by three distinct gangs—the machine men, dinky men, and dump gang. The machine is operated by one engineer and a fireman, with two ground men. There are two men used at the point where cars are loaded to clean up the gravel that spills out of the bucket. There are two dinkies with an engineer and brakeman, and six men as a rule in the dump gang. In addition there are two men who are kept busy on track work, repairing, tamping, straightening, etc., two teams hauling coal and supplies, a blacksmith and helper repairing cars, the breakage of which is very great, a foreman and a timekeeper are always on the work. Since the embankment was completed and the surplus gravel has become the property of the contractor, there have been about six men employed on the gravel plant. All the foregoing work was carried on day and night until January 1, 1915, when the extreme cold weather caused so much delay that it was deemed advisable to shut down for a short time.

The contract is one that will result in unusual economy to the Park Board, as the contractor is required to furnish all material and labor and the necessary machinery, and is paid the actual cost plus a percentage with a fixed limit as to the unit cost. All surplus gravel is paid for by him, and this one item will repay the Park Board nearly one-third of the contract amount.

NOTES ON THE CONSTRUCTION OF A 48-INCH REINFORCED CONCRETE SEWER

By Albert A. Chenoweth, C. E., '15
Jr. W. S. E.

The city of Muskogee, Oklahoma, had at the time of the construction of its main outfall sewer a population of about 30,000. The town is so situated that the drainage is easily accomplished. About three-fourths of the area within the city limits slopes directly south towards Coody's Creek, the remainder falling off toward the northeast. Coody's Creek, a small stream having its source in the southwest part of the town was being used to provide a means of sewage disposal. As the population was rapidly increasing the need of an outfall sewer was recognized, one that would carry the sewage entirely away from the city, at least as far as the Arkansas River, a distance of seven miles. Mr. Alexander Potter, of New York, who was retained as engineer finished the plans in May, 1911, at which time the contract was let, for 10.63 miles of sewer, varying from 48″ to 18″ in diameter, the pipes to be of concrete and vitrified tile.

The job was well under way by the first of June. The writer was employed as resident engineer on the four sections to be built of 48″ reinforced concrete pipe, a total length of 20,700 feet. The making of such an amount of reinforced concrete pipe at an average distance of six miles from a railroad involved transportation questions of some magnitude. Other branches of municipal and private construction commanded all available teams, since the larger amount of such work was in the city itself. To offset this the contractor decided to use a steam tractor, which could easily haul six 3-yard cars. This train made three 6-mile-average trips in an eight hour day, a total of 36 miles over ungraded earth roads. Usually cement, sand and gravel were hauled in about the proportions to be used each day, thus enabling the contractor to keep his pipe making gang at work steadily. The cement was tested by the city chemist according to standard specifications, he reporting the result of the seven day test to the contractor, the engineer and the City Engineer's office simultaneously. The forms used were patented, their cost being payment of a royalty of $1.20 per lineal foot of finished work. Only 150′ were available, necessitating a careful watch that the contractor, in his zeal to push the work ahead, should not remove the forms too soon, thus risking the safety of the pipe. Under the warm southern sun, the minimum time of removal was five hours, allowing the pouring of about 270′ of pipe each eight hour day. A 1:6 mixture was used, always made very wet, so that it could be churned well, thus giving against the oiled steel forms a very smooth finish. The oil used permitted of easy and safe removal of the forms. The reinforcement used was a standard mesh, ¼″ circumferential bars, tied together at 3″ intervals with No. 14 wire. A great deal of trouble was experienced in making the laborers keep the reinforcement in place, but after some time a few men learned to do it very well. In freezing weather the danger of frosted concrete arose. To obviate this a crude oil lamp was kept burning in each pipe for 30 hours after pouring, and in addition large brush fires were kept burning throughout the pipe yard. The water used in mixing was also heated, but in spite of these precautions some of the pipes showed marks of frost. Those so marked were found to be fairly sound when examined the next spring after a winter above ground. The pipe making by great effort was kept ahead of the trenching, which on account of the soil encountered was not done very rapidly.

The heavier work of trench excavation was done by a Marion shovel, mounted on four trussed beams, which were carried on rollers on either bank of the trench. It was possible to dig a maximum of 17′ with this machine, and in case slightly greater depth was required the remainder was thrown ahead with hand shovels into the face of the cutting. Excessive vibration under the action of the shovel loosened the earth of the trench walls and necessitated careful bracing in material that would probably otherwise have required none. The work under the shovel was braced as shown in Fig. 2. Quite the largest amount of the sewer lay at a less depth than the most economical working depth for the shovel, so a Municipal Excavator was used in addition. This machine cut a regular, smooth-sided trench, 66″ wide. Its most economical depth was 9′ while the shovel did best in a 15′ trench. The trench dug by the excavator in general required but very little bracing; the pipe laying also followed closely, the bottom of the ditch being well graded by the machine.

The greatest difficulty found in laying the pipe was in trying to get a reasonably smooth joint. After a few hundred feet had been laboriously tamped into a firm bearing, the suggestion of a 2″ x 12″ plank to be laid continuously in the bottom of the trench on the centre-line was eagerly adopted and worked wonders in saving labor and securing better joints. The trench in all cases was excavated to a square bottom. This made necessary very careful watching to prevent a chance of the failure of the pipe to carry its load of back-filled earth, through a lack of solid support in its lower half. The sewer was laid on a grillage of specially shaped heavy timbers in soft wet ground or in cuts of less than four feet, the amount of the latter being some 400′. It was in the shallow trench that the men worked up their greatest speed; 416′ being by long odds the best eight hours' work.

Wages paid were as high and in certain cases higher than in the city, both to the laborers and foremen, yet the job was nearly always short-handed, and a change of foreman for a gang was as likely to come each month as not. Under such conditions the work slowly forged ahead, reaching completion before a year had passed.

ROPE TRANSMISSION

By E. M. Carver, M. E., '09

The following brief discussion of rope transmission is no way intended to be an exhaustive or adequate treatise on this very interesting subject, yet many engineers well versed in other types of drives have a signally limited amount of information concerning the extension and scope of rope driving. The writer has thought that the description of a few typical drives would prove of interest and possibly give the uninitiated an insight into the almost universal manner in which this very flexible type of transmission is applicable, not only to the conditions of perfect simplicity, but also to the requirements of the most intricate and complicated character.

The introduction of ropes for the mechanical transmission of power is commonly accredited to C. F. Hirn, of Logleback on the Rhine, who in 1852 conceived the idea that by converting power into the highest practicable velocity of the transmitting organ, the size and weight of that organ might be reduced to minimum dimensions, and its length therefore extended indefinitely, its velocity being reconverted into power at the operative point.

The adaptability of ropes to do the work of belts, without the limitations of the latter, was soon recognized and in England they immediately began to be applied for main drives as substitutes for very heavy, long, and expensive belts. By the multiplication of single rope belts running in grooved wheels, larger powers may be delivered, but the aggregation of single ropes carries limitations which confine its usefulness to comparatively narrow bounds. It is impossible to secure uniform length for several independent ropes since the stretch cannot be controlled and it is impracticable to apply tension devices separately to a number of ropes running so close together. Hence to obtain adhesion to the wheels and thereby secure tractive force it becomes necessary to use large heavy ropes in pinch grooves which must be deep and spaced far apart to prevent the ropes from jumping and fouling each other.

The principal advantage of the English system is that although one or two of the ropes may break it does not materially affect the drive, yet when these loops are replaced, the new rope rides higher in the pinch groove, since the old ropes having been under working strain are worn and have been stretched to a smaller diameter. In drives where the sheaves are of unequal diameter this condition causes a differential of pitch diameters which is certain to cause a change of speed and slippage in the grooves. Therefore, for the successful installation of an English drive it is essential that the driving and driven shafts shall both be horizontal, not far from the same level, and at a considerable distance apart. Under these favorable conditions the English system is efficient and economical, but its application is limited for obvious reasons.

This in brief was the condition of power transmission by ropes in 1883, when Wallace H. Dodge, founder of the Dodge Manufacturing Company, proposed to employ a single endless rope in multiple wraps, and to apply thereto a proper tension device; and thus at one stroke overcome the former limitations and make the rope drive universally applicable for all transmission purposes, regardless of distance and direction. This later type of drive is called the American system, one continuous endless rope is used, winding around the sheaves successively in the several grooves, making as many complete wraps as may be required by the power transmitted. From the last groove on the driving sheave the rope passes over single-groove tension and winder idlers which combine to give the rope fair lead to the first groove of the driven and also to control and regulate the tension in the ropes throughout the drive. The weighted tension carriage can be made to give just the right amount of tension which may be required to accommodate changing conditions by manipulation of the weights used.

Thus rope driving passed through its experimental stage and in 1885 when the American system was patented, drives of this type soon made their appearance, as in its new perfected form, all haphazard elements had been eliminated and it was possible to intelligently design a drive suitable for the work it had to do.

Designers of rope drives early discovered that it was absolutely necessary to give especial attention to sheaves in regard to diameters, groove forms, accuracy, balance and true running.

Rope wear is greatly increased by the use of small sheaves. The frequent bending and then straightening of the rope, in running onto the sheaves and off again, is a continuous performance, and excessive degrees of such bending must be avoided if the rope is to have a fair length of life. The wear of the rope is both internal and external. The internal is caused by the sliding movement of the fibres on each other while bending around the sheaves, the external by the slippage in the grooves of the sheaves. This wearing is assumed to be directly proportional to the speed. Moderate bending is not particularly injurious, but beyond certain limits the action grows rapidly worse. Experience has proven that good Manila transmission rope may be satisfactorily worked on sheaves with diameters as small as 40 times the rope diameter, but the durability of the rope will be increased if 50 or 60 diameter sheaves are used.

The 60 degree groove is used for the driving and driven sheaves in the American system and while being efficient in operation, it gives at the same time a minimum of rim width and thickness which means economy of space and provides a light and inexpensive sheave. Idler sheaves have U grooves if the ropes have sufficient arc of contact to insure no slippage. In the U groove the bottom radius is made the same as the rope itself; this holds the rope central and allows the rope to enter and leave the sheave free and clear, without chafing.

Especial attention in regard to accuracy and uniformity of all grooves is absolutely essential to perfect success. The pitch diameter must be exactly the same for each groove as the slightest differential will produce variation in the rope speed and cause change of tension or slippage which will immediately be reflected in the operation of the drive and produce undue wear on the rope.

The breaking strain of first-class Manila transmission rope may be taken as $9000 \times \text{dia.}^2$ and for continuous service, practice has shown that to give long life it is not advisable to work the rope with a tension of over $^1/_{50}$ or 2% of the breaking strain, therefore, $\frac{9000}{50}\,\text{dia.}^2 = 180\,\text{dia.}^2$ which is the maximum allowable working tension.

There is quite a difference of opinion among experts as to the proper method of figuring the H. P. of ropes. The differences arise over the question of centrifugal force and what has been termed "adhesive tension." The following formula has been used by the Dodge Manufacturing Company for several years and experience has proven it to be entirely satisfactory for the American system:

$$\text{H. P.} = \left(T - \frac{Wv^2}{Rg}\right) \times \frac{V}{33000}$$

T = Working Tension or 2% of Ultimate Strength.
W = Weight of rope per ft. = $.34\ D^2$
D = Dia. of rope in inches.
R = Radius of sheave in feet.
g = 32.2
v = Velocity in feet per second.
V = Velocity in feet per minute.
$9000\ \text{dia.}^2$ = Ultimate Strength.

The following table is based upon the above formula all sheave diameters being 40 diameters of the rope.

Rope Diam.	Min. Diam. Sheave	Horse Power of One Rope at Different Speeds on Sheaves of Minimum Advisable Diameters											
		500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000
¾	30	1.5	3.0	4.5	5.8	7.1	8.1	9.0	9.7	10.2	10.4	10.3	9.8
⅞	35	2.1	4.1	6.1	8.0	9.7	11.3	12.6	13.7	14.5	15.1	15.2	15.0
1	40	2.7	5.4	8.0	10.5	12.8	14.9	16.8	18.4	19.7	20.6	21.1	21.2
1⅛	45	3.4	6.8	10.2	13.3	16.3	19.1	21.6	23.8	25.6	27.0	28.0	28.5
1¼	50	4.3	8.5	12.6	16.5	20.3	23.8	27.0	29.8	32.3	34.3	35.8	36.8
1⅜	55	5.2	10.2	15.2	20.0	24.6	29.0	33.0	36.6	39.7	42.4	44.6	46.1
1½	60	6.1	12.2	18.1	23.9	29.4	34.6	39.5	43.9	47.9	51.3	54.1	56.2
1⅝	65	7.2	14.3	21.3	28.1	34.7	40.9	46.7	52.1	56.9	61.1	64.7	67.6
1¾	70	8.3	16.6	24.7	32.7	40.3	47.6	54.5	60.8	66.7	71.9	76.4	80.1
2	80	10.9	21.7	32.4	42.8	52.9	62.6	71.8	80.4	88.5	95.7	102.2	107.8

Straight open drives of simple design are admirably illustrated in Figs. 1, 2, 3, 4 and 5. Fig. 1 shows a 1000 H. P. motor drive at the Niagara Falls Hyd. P. & M. Company, Niagara, Falls, N. Y.

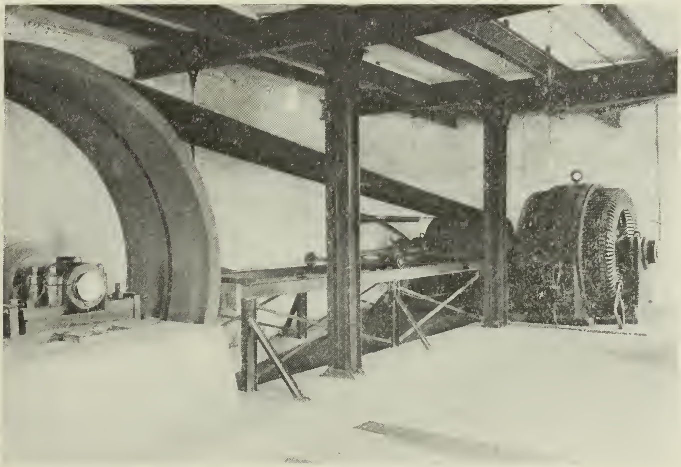


Fig. 1.

Figs. 2 and 3 show two 1500 H. P. drives from a 3000 H. P. engine at the Barrett Manufacturing Company, Peoria, Illinois, each of these drives having 25 wraps of 2-inch rope.

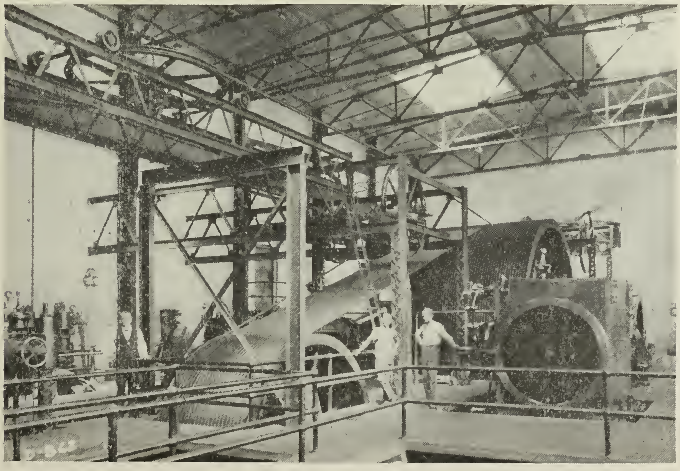


Fig. 2

3000 H. P. Engine Showing one of two 1,500 H. P. Rope Drives.

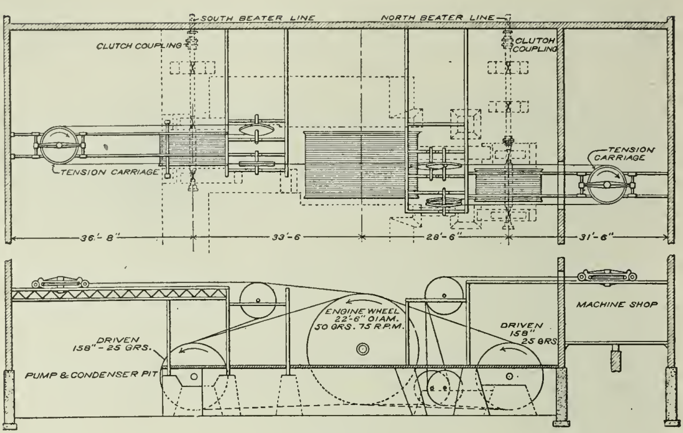


Fig. 3.

Plan and Elevation of Above Drives.

An extremely compact drive at the Diamond Rubber Company's plant, Akron, Ohio, is shown in Fig. 4. Note the arrangement of the tension carriage, it being placed in the basement.

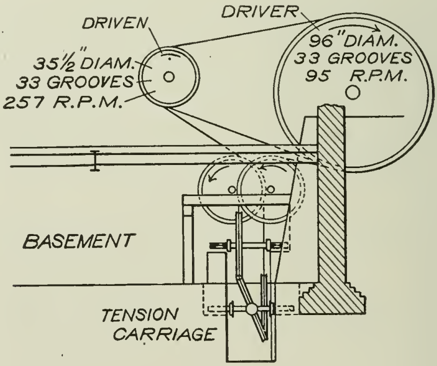


Fig. 4.

An Extremely Compact Drive.

The Mechanical Rubber Company of Cleveland, Ohio, also have a drive (Fig. 5) which illustrates the short center proposition and shows how the tension equipment may be located at any convenient point.

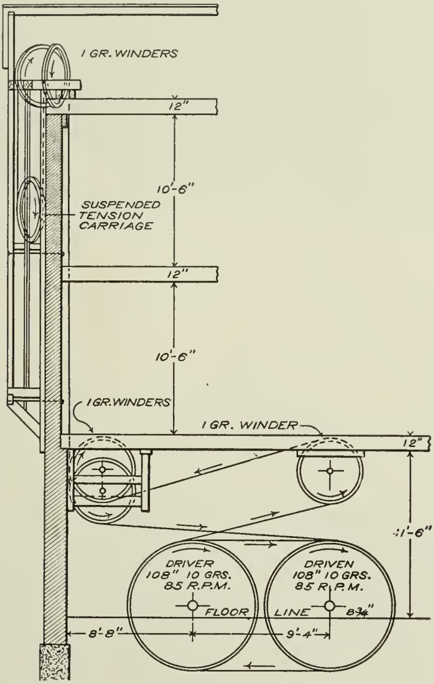


Fig. 5.

Mechanical Rubber Co., Cleveland, O.

For the heavy drives it is often desirable to mount either the driving or receiving sheave on a clutch quill (Fig. 6). When the clutch is out the quill rests motionless in its own bearings, and thus all transmission losses are eliminated. This arrangement makes a very flexible drive and as the quill takes care of the bending stresses due to the tension in the ropes and the weight of the sheave, the shaft need not be in excess of that required to transmit the power.

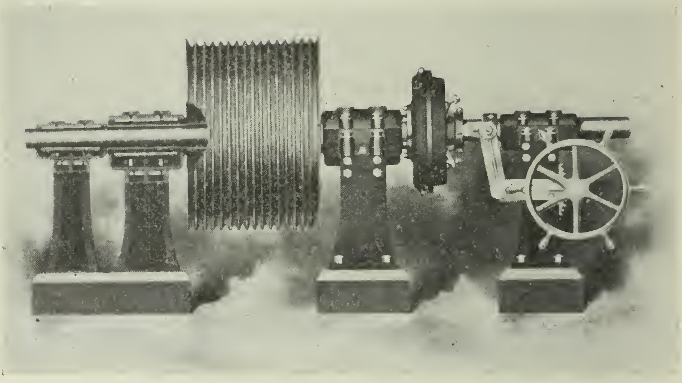


Fig. 6.

A Typical Quill Unit for a Rope Drive.

Connecting shafts need not be parallel as by altering the form of grooves and introducing idlers, it is possible to accommodate any angle or difference in elevation that may be encountered (Figs. 7 and 8).

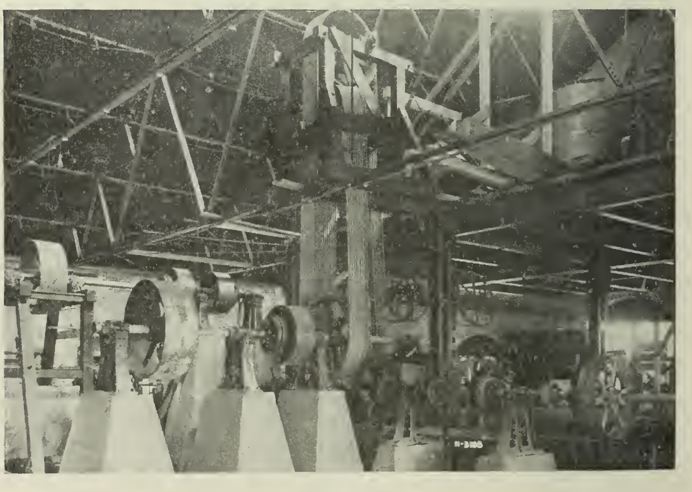


Fig. 7.

Connecting Two Main Lines at Right Angles.

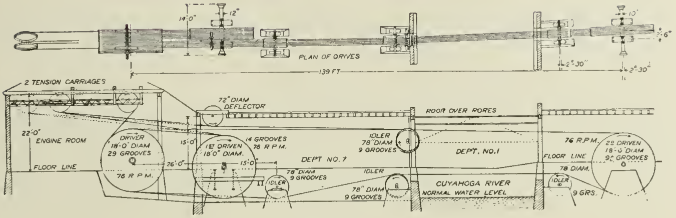


Fig. 8.

Connecting Two Line Shafts not quite Parallel.

Transmission of power to detached buildings or isolated shafts may readily be accomplished as shown in Figs. 9 and 10.

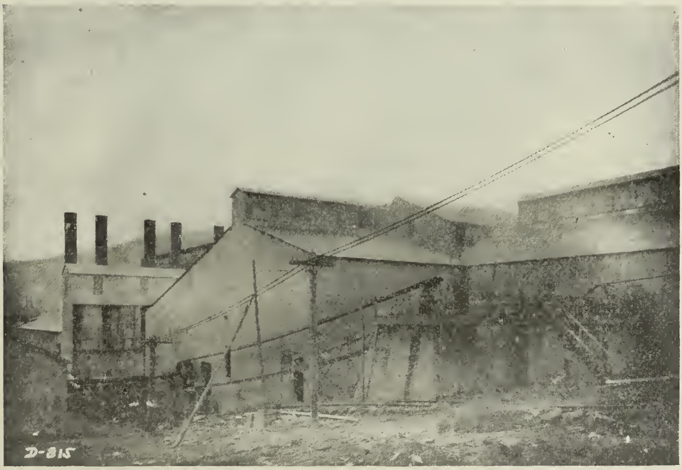


Fig. 9.

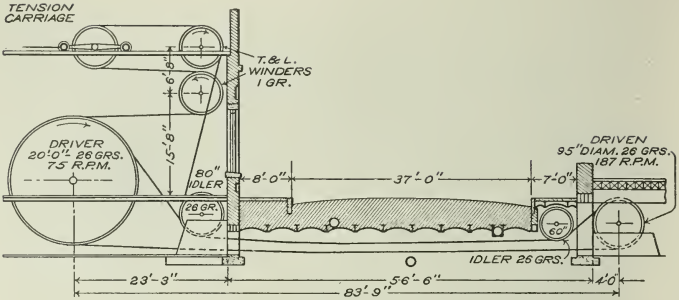


Fig. 10.

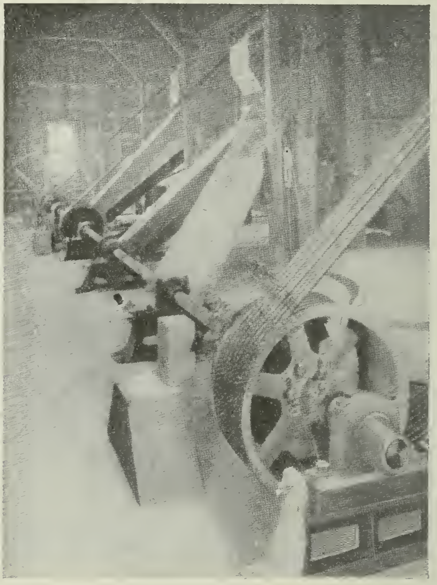


Fig. 11

Reverse Drive for Elevator Counter Shaft

Reversal of motion is taken care of by either crossed ropes or by the use of reversing idlers. Figs. 11, 12 and 13 show typical illustrations.

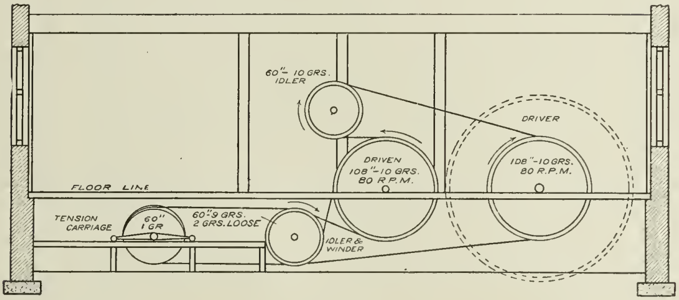


Fig. 12

Reversal of Motion on Short Centers

Drop-off drives from a main or driving shaft to receiving shafts on the several floors of a building are shown in Fig. 14. These drives are made extremely flexible by the use of clutches on each shaft.

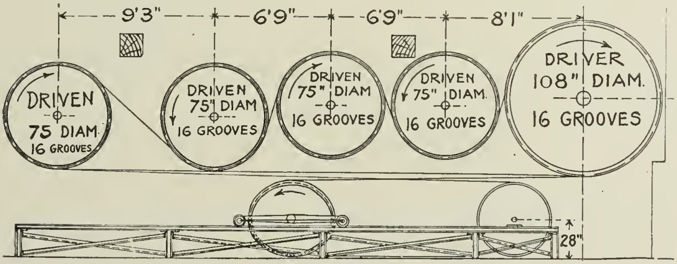


Fig. 13

Simple and Compact Arrangement of a Drive

Fig. 15 illustrates another drop-off drive in the Arnold Print Works, North Adams, Mass.; here 20 lines are driven from the main driving shaft, in relays of 10 ropes each. From the 20 Gr. main driver 400 H. P. is transmitted, dropping off one wrap at each of the first nine shafts; 11 wraps drive the tenth shaft, which is the relay point for the second drive of 10 wraps or 200 H. P. from here the drop-off continues to the last shaft which has only one rope.

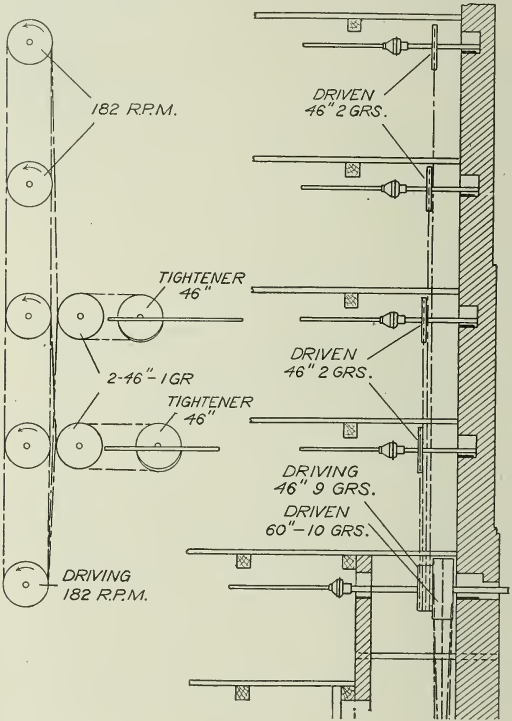


Fig. 14.

Typical Drop-off Drive.

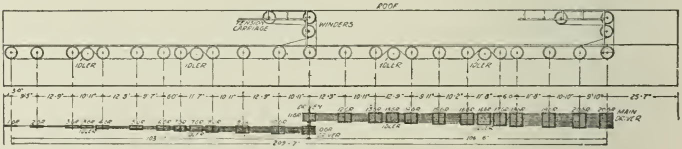


Fig. 15.

Each Shaft Driven Directly from the Main or Relay Line.

ONE PROBLEM IN THE SCOTT-CONNECTION OF TRANSFORMERS

By E. A. Bureau, E. E., '15

(Note:—This article is based on a thesis prepared by B. N. Das Gupta, '14, and the author, with the assistance and guidance of Professor Rowell of the School of Electrical Engineering.)

When it is desired to obtain two phase power from a three phase source, it is customary to use the Scott scheme of connecting the transformers. Two transformers are used, one having an 86.6% tap and the other a 50% tap, the connections being made as shown in Fig. 1. Fig. 2 shows the vector relation of the supply voltage as applied to the transformer primaries, the dotted lines indicating the primaries. The vector relation of the secondary voltages are shown in Fig. 3.

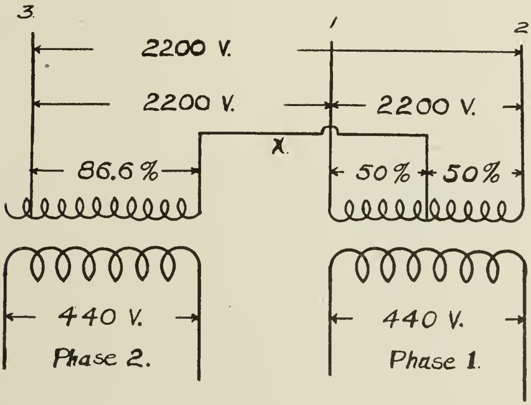


Fig. 1. Connections of 2.5 KW. Transformers.

Theoretically, the voltage relations shown are correct and proper, and produce the desired result. Practically, the scheme does not always work so well under load conditions. A transformer bank, which is at this time still in use in the

Purdue Electrical Engineering Laboratory, demonstrates very well this failure to fulfill theoretical expectations. This bank consists of two 2.5 Kw. transformers, 2200, 1900-440 volts, Scott-connected. It has for its load a motor generator set consisting of a 5 hp., 5.5 ampere, Bullock two phase motor, direct connected to a Bullock d.c. generator. This combination has never been satisfactory because of the bad unbalancing of voltages in the two secondary phases. Tests at different loads brought out the characteristics shown in Fig. 4. (In referring to Phase 1 and Phase 2, the same notation will be used as is designated in Fig. 1.) The voltage in Phase 2 holds up very well, which makes the resultant regulation comparatively small. However, in Phase 1 there is very bad regulation, even with that phase taking only 60% as much current as Phase 2.

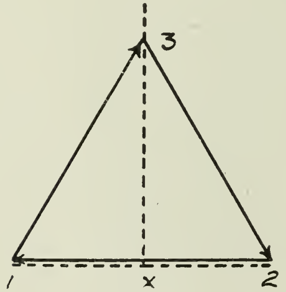


Fig. 2

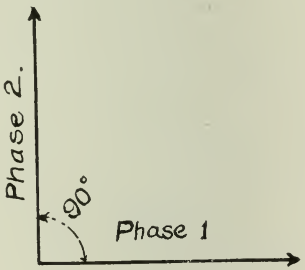


Fig. 3

Poor regulation of a transformer means essentially a large drop of voltage in the transformer, which means voltage loss in its impedance. This impedance drop can be resolved into two components: one, an IR drop in the coil, in phase with I; and the other, the reactive drop at right angles to I. This reactive drop consists of a counter e. m. f. set up by the leakage flux of the transformer coils—the flux of each coil which does not link any other. As a test of the above statements, regular impedance measurements were made on the two phases. As the secondaries were short circuited in turn, voltage was applied to the primary side, At about 60% full load current an impedance drop of 60 volts was measured on Phase 2. On Phase 1, for the same current, the impedance drop across the whole phase (points 1, 2 to 3) was found to be 220 volts. Only 38 volts of this drop was in the part 3-x. The large balance of about 180 volts was therefore practically all leakage reactance drop, since only about 6 volts represented the equivalent IR drop of the transformer as tested.

When a current is sent through a coil, a magnetic field is set up; and, when this coil surrounds one leg of a closed magnetic circuit, most of the lines of force are concentrated in the iron. However, there is some of the flux which takes a part iron, part air path. This is known as leakage flux, since it "leaks" out of the iron path. If a second coil is placed on the iron core, the whole constitutes a transformer. The coil upon which the voltage is applied, is called the primary; and the other, the secondary. When an alternating current is sent through the primary, an electromotive force is generated in the secondary; and this e.m.f. applied to a load, forces through the secondary a current which, according to Lenz's law, sets up a counter m.m.f. and thus opposes the flow of flux due to the primary. This counter m.m.f., which is proportional to the load, produces additional leakage of flux from the primary coil by forcing out, into the air around the secondary, part of the flux that has threaded the iron through the primary. If it were possible to wind the two coils so that they would occupy the same space, their values of m.m.f. would be coincident through-

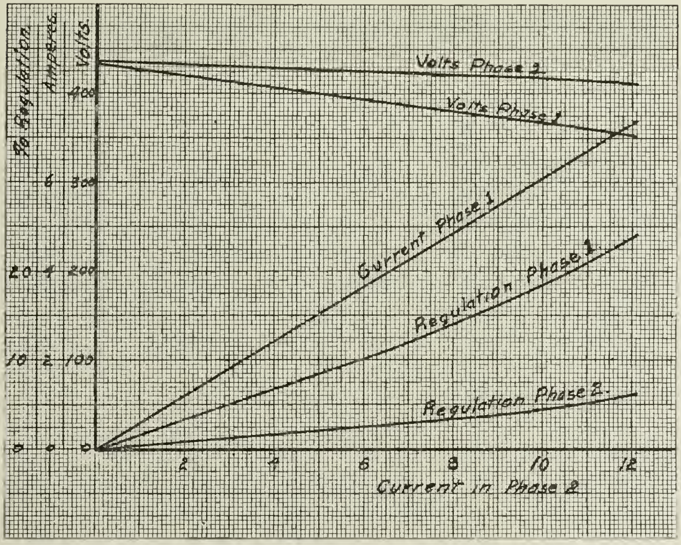


Fig. 4

out but opposite, giving, as a result, no net leakage. Thus the leakage reactance becomes a measure of the magnetic separation of the coils, for the resultant leakage flux is dependent upon the distance between the coils. To illustrate the above statements, tests were made on three different styles of transformers in order to determine the relation between the magnetic separation of two coils and the amount of leakage flux. These transformers were: a Moloney core-type transformer with four coils, two on each leg; a Wood shell-type transformer with sandwiched coils; and a special design Duncan core-type transformer with four concentric coils, each of which were equally distributed about the two legs of the transformer. With the Moloney transformer it was found that between coils on the same leg, with full load current in the coils, the leakage reactance voltage was comparatively small, being only 2% or 3% of rated voltage, but that between coils on different legs this value increased to nearly 20%. In the Wood transformer a like relation was found: the farther apart the coils, the greater the per cent. of leakage reactance. The leakage reactance between any two coils did not exceed 5.8%, and was as low as 0.8% for coils close together. On the Duncan transformer equally good results were obtained. In this case the reactance drops varied between 0.4% and 2%, being directly proportional to the amount of magnetic separation of each pair of coils tested.

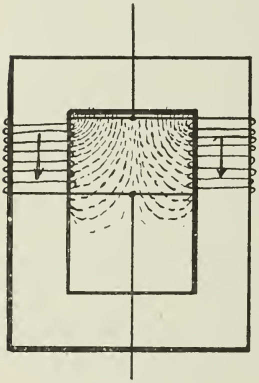


Fig. 5

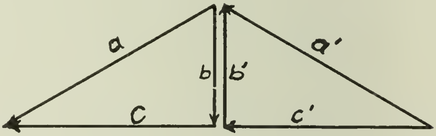


Fig 6

Considering again the results of the tests on the 2.5 Kw. transformer of Phase 1, with the primary coils connected as in normal single phase operation, the impedance drop is only 5% of the rated voltage, while with the Scott connection the impedance drop is nearly 25% of the rated voltage. In view of what has been said in the preceding paragraphs this difference of impedance drop is now easily explained. In normal single phase operation the two parts of the primary are acting in such a way that the m.m.fs. generated by each part go through the iron circuit in the same direction. At the same time the secondaries are placed comparatively close to the primary coils, thus insuring a fairly close magnetic relation between the interacting coils. In the Scott-connection impedance test the two primary coils are energized in such a way that the m.m.fs. of the two primaries buck each other. Therefore no e.m.f is generated in the secondaries because no flux passes through the iron circuit. However, this does not prevent a large quantity of flux from passing through the air (Fig. 5) and thus causing a high reactance voltage drop. In the actual operation of Phase 1 of a Scott connection the two parts of the primary are energized, not by currents of the same phase relation, but by currents of 120 degrees separation. The result is an m.m.f. vector relation in the iron circuit, as shown in Fig. 6. The vectors a and a′ represent the m.m.f. set up by the two primary coils respectively; b, c and b′, c′ represent the corresponding components. The "in phase" components send through the magnetic circuit that flux which generates the secondary voltage. Components b and b′, like the m.m.fs. in the impedance test, buck each other,

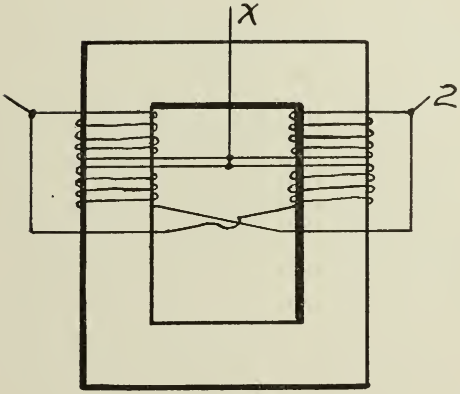


Fig. 7

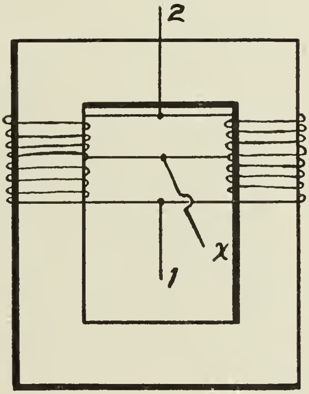


Fig. 8

and are not responsible for any secondary effects, but are the cause of a large amount of leakage flux. The net leakage, thus, is practically all produced by the components b and b′, since the leakage reactance drop, due to components c and c′, is not greater than 5% of the rated voltage. Therefore the natural conclusion is that, in order to diminish the great leakage flux produced by the m.m.f. components b and b′, the two interacting coils, which in this case are the two parts of the primary, must be brought into close magnetic relation.

Since the primaries of the shell-type transformer with sandwiched coils have close magnetic relation, this transformer is a good one to use in a Scott connection. Figs. 7 and 8 show two ways in which the primaries of a core-type transformer may be tapped and connected to give the proper magnetic proximity necessary between the two parts of the primary circuit in Phase 1 of a Scott connection.

In general, it may be said that operating a transformer under conditions which are not normal, may give rise to leakage reactances which are far greater than are popularly supposed to exist. Therefore, when a transformer is expected to be used in special service, it should be designed with subdivided coils, so that close magnetic relation of interacting coils may be obtained.

WINTER SURVEYING IN CANADA.

By A. C. Clarke

The systems of survey in Canada and in the United States have many points of similarity. The general layout of lines with regard to convergence, spacing, and correction and the astronomical references for these lines, resemble each other closely in both countries. In Canada, however, several unusual features are encountered in the field work. The writer feels that perhaps a general description of the surveying operations as carried on in Canada during the winter months will serve to point out some of these distinctive features and will at the same time furnish some idea of the work that is done and the manner of its accomplishment during a season of the year which ordinarily means inactivity to the surveyor in this country.

First, a brief description of the field organization of the Canadian Surveys Department. There are three general divisions of the field engineers. To take them in the order of their work, we have the "base-line" men, the "sub-dividers," and the "resurvey and restoration" surveyors. The "base-line" engineers, as the name implies, are responsible for the "precise" work of the system and it is their especial care to produce, with all accuracy, the reference meridians and the connecting base lines which block out the country and to establish exact monuments for the subsequent work of the "sub-dividers." This second group of engineers are usually contractors running interior section lines on a mileage basis and tying in with a moderate degree of accuracy to the work of the "base-line" men. The third division is made up of those engineers whose duty it is to retrace lost surveys and restore old marks and monuments.

It is obvious that the discovery and restoration of lost monuments would be seriously hampered by cold weather and heavy snows and equally plain that the efficiency of a contractor's party would be materially reduced by the short winter days and the necessity for speed in a snow covered country and with instrument work made difficult by a temperature of 50° below zero. The base-line surveyors, however, have none but their own monuments to heed and carefully precise work is, with them, of far more importance than any mileage record. Winter surveying, then, is confined almost entirely to the work of the base-line operators.

Briefly, the system of survey consists of a number of reference meridians approximately 190 miles apart at the 49th parallel of latitude and converging toward the Pole. The base lines are of 6-mile chord sections, east and west, and are spaced 24 miles apart, numbering toward the north from the 49th parallel as a first base. These lines are marked by iron posts and mounds and pits at every ½-mile station and it is the duty of the surveyor to see that a "sky line" is cut through all timbered country and that well-sized trees are blazed along both sides of the line at intervals of not more than 50 links. It is still further the duty of the base-line engineer to conduct a rough topographical survey of the country for 12 miles on either side of his line, to construct a map from the data so obtained, and to include in his report a description of the soil, watered areas, geology, timber, and animal life within the range of his observations.

The average "base-line" party consists of a chief engineer, two assistants, two chainmen, a picket man and five axemen for the transit party, a rodman for the level work, some three or four "pack horse" men, and a cook and cookee. It is seldom that the party numbers over twenty men.

The summer work differs but little from the surveying carried on along the same lines in this country. Progress is slow, seldom averaging more than four miles per week of actual line. The camp is moved ahead about once a week, each move necessitating the blazing and cutting of new pack trails since base-line work is always far in advance of any settlement.

The arrival of winter, however, causes a number of changes both for the camp and the men. Pack horses are generally superseded during the cold weather by sleighs of various forms since open swamps, rivers, and lakes can be utilized as roads without the necessity of cutting timber. A flat sleigh, 18″ wide by 10′ or 12′ long can be drawn by one horse and will replace the work of a dozen pack ponies and still require less road cutting.

The men adopt a dress very similar to that found in the lumber camps of the northern States—heavy mocassins, mackinaw sox and pants and coats, flannel shirts, heavy sweaters, woolen caps, and woolen mitts with a soft leather covering. Such an outfit furnishes ample warmth provided always that proper drying by the fire at night prevents the donning of damp garments in the morning.

Each tent is provided with a wood-burning camp stove of the collapsible box type and ten minutes of a good pine fire will suffice to heat a properly erected tent to a very comfortable degree. A ten ounce weight of duck furnishes a heat-retaining, wind-proof dwelling place.

The tents are pitched on the ground after the snow has been removed from the site. Guy ropes are fastened to trees felled near the side walls of the tent. The burlap flap around the bottom of the walls is turned out and snow is piled on it to a depth of two or three feet. This serves the double purpose of anchoring the tent and of banking it against the wind. The "floor" of the tent is of spruce boughs piled as thick as the energy or taste of the owners demands. Upon these boughs as a mattress is spread the bedding—usually three pairs of blankets, or perhaps an eiderdown quilt, fastened into a sleeping bag and protected by a waterproofed covering of canvas or light rubber.

Surveying operations continue through the winter months just as in the summer. Progress is, of course, somewhat slower because of the short days and an average of three miles per week is considered good work. It is not unusual to average less than six working hours per day through December and January. The reason for this will be seen when it is understood that daybreak is about 7:30 a. m. and darkness begins again about 4:30 in the afternoon. Deducting from the intervening nine hours at least two for traveling to and from the line and another hour for noon lunch, there is a balance of only six hours for actual work. The difficulty of cutting in frozen timber does not seriously delay the work as this factor is largely compensated for by the fact that the axemen work much harder and more consistently in cold weather.

The instrument men have a number of little problems to solve during the winter's work. Perhaps the first of these is to learn to handle an instrument literally "with gloves." Bare-handed manipulation is out of the question as the metal freezes the flesh almost instantly. Light knitted-silk gloves afford sufficient protection, however, and do not interfere with the careful adjustment of the screws on the instrument. A clouding of the lenses is often caused by a hand or face brought too closely to the glass and tangent screws are sometimes frozen solid as a result of the moisture from the breath of the manipulator.

Observing becomes a real task in cold weather because of the numerous adjustments and readings which have to be taken. In Canada, because of the northerly latitude, Polaris can always be observed during the day with a moderately high power telescope. Night observations are almost never taken. Without the drawback of darkness, the task is still sufficiently exacting, however, when the thermometer is reading at 40 or 50 below zero. Observations for the deflection of the magnetic needle which have to be made at certain hours of the day, depending upon the time of the year, the latitude, and the longitude, do sometimes necessitate night work but the manipulations are short and simple and cause the transitman but little trouble.

The work of chaining suffers no change during the winter months. A five-chain tape is used with a one-chain length following as a check. Corrections are applied for slope with a clinometer and an alcohol thermometer replaces the mercury bulb used in warm weather for the temperature corrections.

Monument building, which consists of the digging of four square pits and the erection of a three-foot pyramid in the center (the iron post being driven at one corner of the pyramid), is, of course, much more laborious work in frozen ground. The number of these monuments to be erected is not large, however, because of the slow rate of progress and it is seldom that this branch of the work delays a forward movement.

The topographical work becomes a real pleasure during the winter months. With no foliage to obstruct the view, snowshoes to facilitate travel, and open water no longer a hindrance, the assistant in charge of the exploring finds himself able to cover a much larger area of country to a distinctly better advantage than in the warmer weather. For these reasons, compass surveys of lakes and rivers are always postponed, if possible, until the cold weather has arrived.

A comparison of the two seasons from a working standpoint brings out, for the base line engineer's consideration, a number of advantages in favor of winter. The ease with which supplies can be transported, and the ability to keep supplies, particularly fresh meats, are alone almost enough to swing the balance in favor of cold weather operations. As a rule, the men are better workers during this season—a fact easily accounted for when one considers the short hours, better food, and the absence of mosquitoes and black flies which make the summer months almost unbearable at times. The rough comforts of the camp are always developed to the highest degree during the winter season and the long hours under cover are frequently used to convert the tent into a semblance of a real home. If we add to these facts the statement that line operations are but little hindered and say, then, that such hindrance is more than counterbalanced by the increased efficiency of the topographical party, it should be plain why the winter months are regarded as the best season for base line work in Canada.

The Purdue Engineering Review

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Organization

The Editorial Staff of the *Purdue Engineering Review* has undergone a reorganization. A new Constitution has been adopted by the Engineering Societies, which provides for the different departments of the staff as they now stnad. The electing of only one assistant to each department was made possible by the addition of the Chemical Engineering Society, and under the present organization a complete understanding of duties will be promoted. The addition of a Permanent Treasurer will also provide a means of furthering a better organized business department.

A Step Ahead

For many years it has been desirable to have the Undergraduate express his ideas in an intelligible manner. It has also been true that with its mushroom growth, Purdue has men in its Academic courses who have had very exceptional training and experiences. There will be found in this issue several very interesting articles written by undergraduates. This is an experiment that will no doubt prove a success.

Department Notes

SCHOOL OF CIVIL ENGINEERING

THE LABORATORY FOR TESTING MATERIALS

During the past year an Impact Machine and a large torsion testing machine have been installed, which provides for tests in compression and flexure. The Impact machine formerly installed, provides for tests in tension so that the University is now prepared for various kinds of impact tests of materials. The research in progress in the laboratory includes investigation of methods of improving the manufacture of concrete sewer pipes; the investigation of the properties of alloy steels under quick applied and alternating stresses; the investigation of the best division by screening of the output of Indiana gravel beds.

HYDRAULIC LABORATORY

The new installations of machinery in the Hydraulic Laboratory are now complete. The new construction includes a concrete channel, 8 feet wide with large weirs, and a 50,000 pound scale for weighing the flow. Underneath this channel is a large underground reservoir. There is a 12 inch water turbine and a 20 inch centrifugal pump connected up with a steel pressure tank from which also provision is made for a study of discharge through orifices and nozzles under high pressure. This laboratory now has a capacity of 8,000 gallons per minute and the available head of 500 feet. This finely equipped laboratory has been developed by changes in the former machine shop at a very small cost. The experimental work under way includes the flow of water through bent pipe and valves, of the flow of water in concrete channels and also the resistance caused by different forms of bridge piers.

SPECIAL RESEARCH

Professor Albert Smith has completed a very patient and difficult study of the stresses in steel frames of high buildings caused by wind forces.

Professor Albright has continued his measurements of the deformation of railroad tracks under different operating conditions, for the purpose of throwing light on the proper design of ballast, ties and rails.

Professor Geo. E. Martin entered upon his duties as Assistant Professor of Highway Engineering and has spent a larger part of his time in highway extension throughout the State of Indiana. Purdue Road Schools are being held in various districts of the State at which practical problems peculiar to Indiana are discussed.

ENGINEERING CAMP

The engineering camp of the summer of 1914 was held on the State Forest Reserve near Henryville, about 20 miles south of Kentucky, and this summer will probably be held at Pentwater, Michigan. This camp has proved a great success, not only in equipping students as engineers, but has generated a general effectiveness that shows itself to a marked degree in the work of the Junior year.

INDIANA FLOOD COMMISSION

During the past year, the engineering office of the Indiana Flood Commission was installed at the School of Civil Engineering. Professor Hatt as Chief Engineer, was assisted by Professor Wiley, Professor Albright and Mr. Lommel. The report of the Chief Engineer was issued as a bulletin of the Indiana Bureau of Legislative Information.

SCHOOL OF MECHANICAL ENGINEERING

CHANGES IN THE INSTRUCTIONAL STAFF

During the past year several changes have been made in the personnel of the instructional corps of this department. Prof. T. T. Eyre has returned after a leave of absence of one year, in which time he was head of the Department of Mechanics, Hydraulics and Testing Materials Laboratory of Case School of Applied Science. The department has lost in the last year, Prof. L. E. Endsley, who at the present time is Professor of Railroad Engineering at the University of Pittsburg. Mr. A. O. Gates has resigned to take a position as Assistant Sales Manager for the Dodge Manufacturing Company of Mishawaka, Indiana.

The department has had the use of a large amount of apparatus in connection with the Steam and Gas Engineering and the Heating and Ventilating Laboratory.

RESEARCH

Thirteen lines of research were completed far enough to be worthy of publication and a number of problems are still under investigation during the last year. Quite a number af articles and reports were published also during the last year.

SCHOOL OF ELECTRICAL ENGINEERING

The personnel of the instructional corps of the School of Electrical Engineering has not been radically changed this year, Professors Harding, Topping, Rowell, Ewing and Still being its representatives on the faculty and the instructors remaining as before. Messrs. L. L. Bouton of the Kansas Agricultural College, later with the General Electric Co., at Schenectady, and H. E. Phelps of Worcester Polytechnic Institute were added to the staff as assistants.

The west room on the first floor of the Electrical Building, which has been occupied as an office by the head of this school for many years is now being transformed into a reading and conference room for the Purdue Branch of the A. I. E. E. and the three south rooms on the first floor have been devoted to office purposes.

Research work in connection with the high tension laboratory and the test car has been continued during the year and a high voltage voltmeter operating upon an entirely new principle is being constructed in the former laboratory which, it is anticipated, will be of considerable scientific merit. Aside from the usual research and commercial tests which have been carried on there is at present in operation a life and contact resistance test of a large variety of types of signal relays used upon block signal track circuits. This work is being done for the National Signal Association and is attracting considerable attention.

SCHOOL OF CHEMICAL ENGINEERING

The school continues to grow at a healthy rate, the total enrollment this year being 160, compared with 139 last year, including a senior class of 20.

In spite of the unsatisfactory condition of the business world the graduates have all been employed in technical positions in so far as they so desired, and more could have been placed if available.

Some rearrangement of the work has been made, several subjects being transferred to more effective parts of the course.

The staff of the chemistry department has been enlarged by the appointment of Dr. H. E. Loomis, assistant professor in Bowdoin College, to take charge of physical chemistry, formerly administered by Professor Mahin, who now directs the work in quantitative analysis only.

It is expected that some of the seniors in chemical engineering will receive instruction in physical chemistry next year and hope that arrangements can soon be made for a year's work for all in this increasingly important branch of chemistry.

Research work has been conducted this year on the destructive action of chemical solutions on concrete, the efficiency of automobile fuels, and the properties of lubricating oils.

Engineering Library

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Engineering Review Authors for 1916

MR. GEORGE DeA. BABCOCK (*"The Exact Control of Manufacture"*) was born in Corvinne, Utah, in 1875 and received his preliminary education at the Fairfield Military Academy. In 1904 he graduated from Purdue, receiving the degree of B. S. E. E. Before entering Purdue he had some experience in teaching and after graduation he accepted the position of Professor of Mechanic Arts at Syracuse University. In 1907 he became production manager of the H. H. Franklin Mfg. Co., which position he holds at the present time. He is a member of the Taylor Society. He is the author of "Results of Applied Scientific Management," an address before the Metal Trades Association in 1914, and reprinted by the "Iron Age;" "Routing Schedule and Despatch," an address before the Efficiency Society and reprinted by "Iron Age;" "The Executive's Problem," an address before the Manufacturers' Association, reprinted by "Iron Age;" as well as many other articles printed in technical magazines, and addresses before technical societies on the general subject of manufacturing efficiency. Mr. Babcock is generally recognized as being one of the leading authorities in the country on the subject of the application of the principles of Scientific Management.

MR. A. H. BRYAN, A. C., M. S., (*"White Sugar—Cane or Beet?"*) was born in Indianapolis, Ind., in 1874. In 1892, he graduated with honors from the Shortridge High School of that city and was assistant instructor in Chemistry at that institution from 1892-1896 and Asst. City Chemist of Indianapolis from 1893-94. In 1896, he entered Purdue University, graduating two years later with a B. S. Ch. E. degree. From 1897-98, Mr. Bryan was assistant to Dr. W. E. Stone, then Professor of Chemistry at Purdue. From 1898-1901, he was Asst. Chemist of the Indiana Experiment Station; from Jan. to Sept., 1901, Chemist of the Indianapolis Rubber Co.; 1901-1907, Chemist for the American Beet Sugar Co. of Rocky Ford, Colo.; 1907-1909, Asst. Chemist and from 1909-1914, Chief of the Sugar Laboratory, Bureau of Chemistry, U. S. Dept. of Agriculture; and from 1914 to date, he has been Supervising Chemist of the Arbuckle Bros. of New York City. Mr. Bryan is a member of the Indiana Academy of Science, Washington Academy of Science, American Chemical Society, Association of Official Agricultural Chemists, Vereins Deutscher Zuckertechniker, and the National Geographic Society, and has contributed many articles to the technical press, among which are, "The Sugar Beet," "The Chemical Composition and Analysis of Imported Honeys," "The Use of Light Filter Cell in Polarizing Sugars," "Precipitation of Reducing Sugars with Basic Lead Acetate."

MR. F. F. CHANDLER (*"Is the Answer Yes or No?"*) was born in Indianapolis in 1876 and attended the schools there before entering Purdue. He was a teacher of Advanced Physics in the Indianapolis High School for two years before coming to Purdue. He received the degree of B. S. M. E. in 1899. After graduation he was an assistant at Purdue for a year and then became Sales Manager of the Chandler and Taylor Company of Indianapolis, where he is located at the present time in the capacity of sales manager. Mr. Chandler has delivered several lectures before various bodies on the subject of "Corporation Management," and is the author of a number of papers and addresses on Power Plant subjects. He is a member of the Indiana Engineering Society.

MR. C. C. CHAPPELLE (*"Coasting Recorders For Checking Electric Car Operation Efficiency"*) was born at Carthage, Ind., and graduated from Purdue in 1895 with the degree of B. S. M. E. From this date to 1898, he was Manager and Treasurer of the Merchants Electric Light Association of Lafayette, Ind., which he organized. From 1899-1910, he was Engineer and Sales Manager of the Denver, Colo., office and later the Western Sales Manager of the Westinghouse Machine Co., of East Pittsburg, Pa. From 1911-14, Mr. Chappelle was Vice-President and General Manager of the Federal Light and Traction Co. of N. Y. Since then he has been Consulting Engineer and Vice-Pres. of the Railway Improvement Co., of N. Y. Mr. Chappelle is a member of the Western Society of Engineers and of the N. Y. Railway Club, and has contributed to the Electric Railway Journal, "Fundamental Principles of Car Operating Efficiency."

MR. A. B. COHEN (*"Expansion and Construction Joints in Reinforced Concrete Viaducts"*) was born at Chicago, Ill., in 1882, and graduated from Purdue with the B. S. C. E. degree in 1905. In 1910 he was given the degree of C. E. by the same institution. Previous to his graduation, he had two summers' experience as rodman and instrument man for the City Engineer of East Chicago, Ill. From June-Dec., 1905, he was draftsman in the Maintenance of Way Dept. of the D. L. & W. R. R. and from Dec., 1905-Sept., 1906, he held the position of Chief Draftsman locating Cut-off Line of the same department. From Sept., 1906-Feb., 1907, he was a draftsman for the C. I. & S. R. R.; March, 1907, he re-entered the Engineering Dept. of the D. L. & W. R. R. as draftsman in the Concrete Dept., and from May, 1907, to date, he has been Engineer of Concrete Design for that railroad. Among Mr. Cohen's engineering designs are the Martin's Creek viaduct, the Tunkhannock Creek and many others, ranging in length to 2230 ft., and in cost to $1,400,000. He is a member of the American Society of Testing Materials and of the American Concrete Institute, as well as an associate member of the American Society of Civil Engineers.

MR. R. G. FLAUGHER (*"Principles of District Drainage Assessments"*), was born at Cayuga, Ind., in 1889 and entered Purdue in the School of Civil Engineering, from which he was graduated in 1912 with the degree of B. S. C. E. Since then he has served in highway work; drainage and mining engineering; railroad surveying; as county surveyor of Vermillion county, Indiana; City Engineer of Clinton and Cayuga, Ind.; and as Valuation Engineer of the Toledo, St. Louis and Western Railway. At various times he has taken work in the Schools of Agriculture of both Purdue and Illinois.

PROF. M. J. GOLDEN, M. E., (*"The Operation of the Control Board"*), Professor of Practical Mechanics at Purdue University, graduated from this institution in 1894. He is a member of the A. S. M. E., the Society for the Promotion of Engineering Education, and the Indiana Academy of Science. Prof. Golden has written the Woodworking, Pattern Making and Foundry parts of the I. C. S. textbooks, "Wood Turning," "A Foundry Course for Schools," and many other articles and textbooks.

MR. G. E. GLOSSOP (*"Fatalities and Serious Shocks Caused by Electricity"*) was born in 1889 at Ft. Dodge, Iowa. After gaining four years' experience in ordnance and seamanship in the U. S. Navy, he entered Purdue in 1910, graduating in 1915 with the degree of B. S. E. E. While at Purdue, he won a "P" in football in 1911, '12, '13, and was assistant football coach at Purdue, 1915. From 1915 to the present date, he has been Mathematics Instructor and Athletic Director of the High School at Rapid City, S. D.

MR. W. A. HANLEY (*"Modernizing a Boiler Plant"*) was born at Greencastle, Ind., in 1886. He received his preliminary education at St. Joseph's College, Collegeville, Ind., and after four and one-half years' experience with the Republic Iron & Steel Co., of Muncie, Ind., and one year with the Broderick Co., of the same city, he entered Purdue in 1907, graduating in 1911 with the degree of B. S. M. E. From that time to the present date, he has been Chief Engineer of the plants of the Eli Lilly & Co., of Indianapolis, Ind. He is an associate member of the A. S. M. E.

MR. A. H. KROM (*"Plans of the American Association of Engineers"*) was born in 1888 at Lockspring, Ind. He graduated from Purdue in 1910, receiving a B. S. E. E. degree. Previous to entering Purdue, he had gained experiences in carpenter and machine shops and in salesmanship. After leaving Purdue, he was electrical operator for the Commonwealth Edison Co. from 1910-11 and Commercial Engineer from 1911-12. From 1912-13, Mr. Krom was Chemical Engineer and Manager of the Chicago office of the Haskins Glass Co. From 1913-14, he was Power Engineer of the Central Illinois Public Service Co.; from 1914-15, City Electrical Engineer of Chicago; and from 1915 to date, Engineer-in-charge of the Chicago office of the State Public Utilities Commission of Ill. Mr. Krom is an associate member of the A. A. E. and of the A. I. E. E. Among his contributions to the technical press are: "Armature Reaction," "Semi-Indirect Illumination," and "Compensation for the Man Between."

MR. W. T. MILLER (*"Condensation Meters"*) was born at Neponset, Ill., in 1884, and is a candidate for the B. S. M. E. from Purdue this year. Before entering this University, he had gained practical experience in handle making; had operated a steam shovel on the Rock Island Lines for 14 months; was in the Indian service for two years; was principal of an Oklahoma Indian school and supervisor of the district Agricultural schools of the Oklahoma State Board of Agriculture for five years. Mr. Miller has had charge of power plants at various times and has obtained considerable practical experience along this line.

MR. HARRY G. RASCHBACHER (*"Notes on Estimating the Growth of Cities"*) was born in Indianapolis in 1881. He graduated from Purdue in 1904 with the degree of B. S. C. E. Since then he has served as Irrigation Engineer for the U. S. Department of Agriculture; Civil Engineer and Irrigation expert in the west; consulting engineer; and Assistant Professor of Surveying. He is a Consulting Engineer at the present time. Mr. Raschbacher is a member of the Western Society of Engineers, and the Michigan Engineering Society. He has published a number of reports on Irrigation Practices for the U. S. Department of Agriculture, and several articles for the Engineering Record, as well as articles for college technical publications.

MR. J. D. RAUCH (*"The Evolution of Excavating Machinery"*) was born at Logansport, Ind., in 1874. He entered Purdue in 1891 and left at the end of his Sophomore year. From 1893-1895, he was employed in a County Surveyor's office; from 1896-1900, he was a draftsman for the Pennsylvania R. R. Co.; from 1900-1902, Assist. Master Mechanic of the L. E. & W. R. R. Co.; from 1902-1903, Mechanical Engineer of the Pennsylvania R. R. Co.; 1903-1906, Chief Engineer of the Wm. Dowling Co.; and from 1906 to date, he has been Secretary and Treasurer of the American Steel Dredge Works, Fort Wayne, Ind., which he organized in 1906 and which was incorporated in 1909.

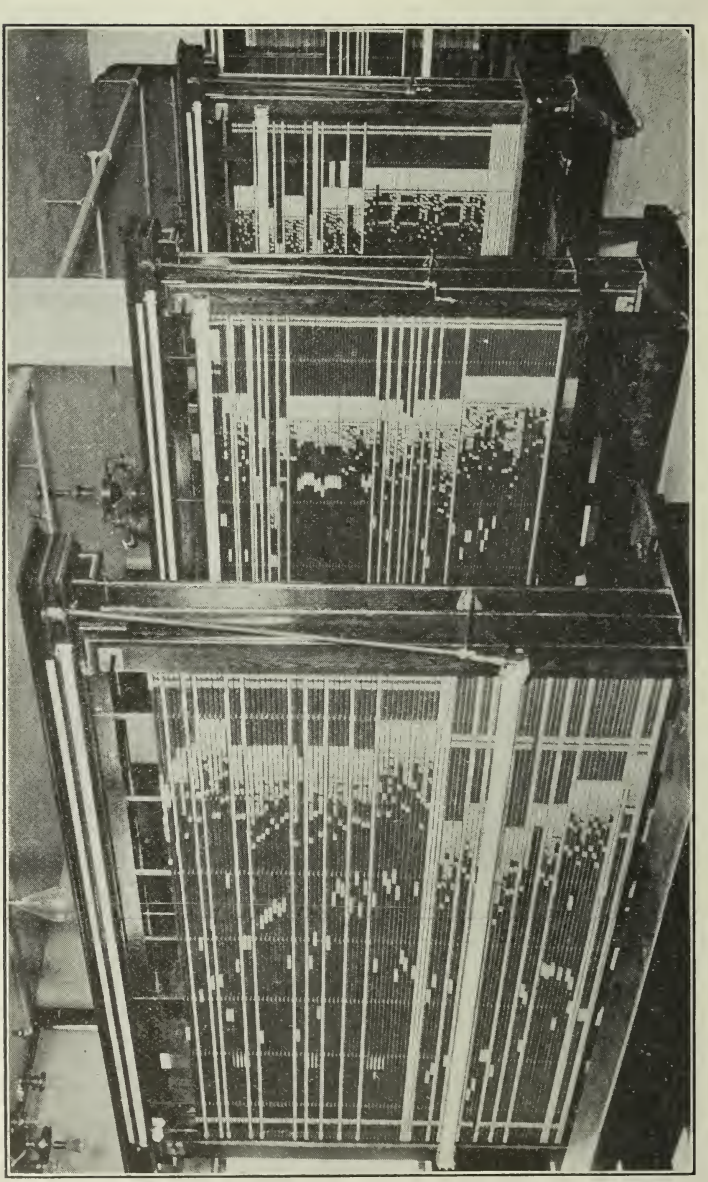
MR. W. E. STANLEY (*"Loss of Head in Pipes, Bends, Valves and Other Fittings"*) was born at Burton, Kans., in 1891. He graduated from the Kansas State Agricultural College in 1912, receiving a B. S. C. E. degree. From Aug.-Dec., 1912, he was bridge inspector for the state of Kansas; from 1912-13, he was employed as chainman on U. S. land surveys; and from 1914 to date, he has been an assistant in the School of Civil Engineering, taking a graduate course in Hydraulic Engineering. He is a candidate for the degree of C. E. and is a member of The Society for Promotion of Engineering Education.

MR. L. E. STIBBE (*"Some Phases of Railroad Traffic Study"*) was born in Valparaiso, Ind., in 1892, and graduated from the high school at Kants, Ind. He graduated from Purdue in 1915 with the degree of B. S. E. E. Since then he has been employed in the Testing Department of the General Electric Company. He is a member of the Schenectady branch of the American Institute of Electrical Engineers.

MR. J. C. TURPIN (*''Some Personal Impressions of Aviation''*) was born in 1886, at Dayton, O. He graduated from Purdue in 1908 with the degree of B. S. M. E. Previous to entering Purdue, he gained much experience in working with automobiles and motorcycles. From 1909-1912, he was an aviator and salesman for The Wright Co. of Dayton, O., being one of the seven members of the Wright Exhibition team. Retiring from the field of aviation in 1912, he entered the sales department of the Packard Motor Car Co., of N. Y. From 1914 to date, he has been a member of the firm of the American Cotton Co., of Boston, Mass.

PROF. L. W. WALLACE (*"Shop Control"*), Professor of Railway Engineering and of Industrial Management at Purdue University, is a graduate of the Agricultural and Mechanical College of Texas in the class of 1903. He received his M. E. degree from Purdue in 1912. Prof. Wallace is a member of the A. S. M. E.; the International Ry. Fuel Association; the Western Railway Club; the Western Efficiency Society; the American Academy of Political and Social Science, and is an Associate Member of the American Railway Master Car Builders Association. He is President of the Indiana Engineering Society. Prof. Wallace has been a frequent contributor to the technical press of many articles on railway subjects as well as of those along industrial lines.

Main Entrance to Purdue University.
Mechanical Building in background.



The Control Boards in the H. H. Franklin Mfg. Company's Plant.

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EXACT CONTROL OF MANUFACTURE*

By George De A. Babcock, '04 †

Synopsis: A discussion of the application of scientific management to a manufacturing business, taking up the principle elements which enter into the intensive control of manufacturing work and explaining in detail how each may be scheduled and despatched with precision. This article is supplemented by illustrations and an explanation of the control boards used in the H. H. Franklin Mfg. Co's. plant, Syracuse, N. Y. to obtain the exact control described by Mr. Babcock in this article.

Recently the writer addressed the Manufacturers' Association of Auburn, N. Y., on the subject, "The Executive's Problem." The theme of this address involved different types of executive action as applied to the conduct of a business. Three fundamental types of executive action were presented, the third one of which is commonly known as Scientific Management. It is a type of management promulgated and practiced by our late Dr. Frederick W. Taylor, in which the executive assumed a more detailed control of work than practiced under other forms; in which facts supplant opinion and exact instructions supplant general orders. Tasks are set for each element of the work and a perpetual check of accomplishment to these tasks is maintained.

I shall go into a somewhat extended discussion of the application of this type of management to a manufacturing business and from examples gathered over a period of four years of its practice in a most intensive form acquaint you perhaps better than in any other way with what repayment may be expected to offset the strenuous effort required for its introduction and continued application.

The writer has been highly favored in the past with an opportunity to present the results of these experiences before Societies, Associations, and Universities, most of which have been recounted in the "Iron Age" magazine. It has been his aim to prepare a discussion on different phases of this work upon each of these occasions. This paper includes but little of the detail of that which has been previously written.

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* Address given before the University Industrial Society, Bridgeport, Conn., December 3, 1915.

† Production Manager, The H. H. Franklin Mfg. Co., Syracuse, N. Y.

Preliminary to any active work in the factory, the management and more important supervisors must at least agree to be in accord with the new efforts and to give their honest support to such efforts. Those responsible for the work of reorganizing will be reflected by successful or chaotic results. If you fail or go into it with a half-hearted or unscientific approach you will be worse off than before you started. If you support and carry it to a successful conclusion, as it will invariably be if carried through, you will marvel at the comfort and lack of discord which permeates your whole works.

The principal elements which enter into a manufacturing effort, arranged in the order in which they will be discussed, are:

- (a) Stock on hand available for production.
  1. Productive materials.
  2. Patterns and dies.
  3. Supplies
- (b) Material and work in process of production.
  1. Buildings.
  2. Machines and equipment.
  3. Materials.
  4. Tools.
  5. Men.
- (c) Money.
  1. In production.
  2. In supplies and indirect expense.

THE CONTROL OF STOCK MATERIALS

Develop a set of controlling records for the stock, which are designed to be absolutely dependable without undue supervision.

Perfect the inspection of incoming materials to the end that inspection precedes receipt into the stock room or records and that no rejections shall occur after such record. To secure this, specifications must be exact and the education of the inspectors with respect to the specification complete.

(*Example*: At the end of our year 1911, the variation in stock room physical inventory with the records was 2½% of the value of charges handled during the year. At the end of the year 1913, the variation was .03%. At the end of the year 1914, the variation was .01% of all such charges.)

Upon this foundation material schedules, in and out of stock, can be attained with unbelievable exactness.

To insure materials being in stock on required dates, the Purchasing Agent must provide for the schedules standard purchasing times for each material class, as forgings, grey, malleable, aluminum, or bronze castings, cold rolled bars, nickel steel bars, etc. These standard times are the minimum number of days in which the representative can regularly bargain, buy and deliver to stock each class or special item. From time to time such list will be modified as changes of conditions require.

(*Example*: The standard list now in service contains seventy-two classes and items. It is dated May 11, 1915, at which time it was last revised. To this date, with all the assumed difficulty of obtaining materials, only six changes have been made in time allowances in this list. At this date 4,000 lots are on order with the Purchasing Agent. About 100 lots are issued to the shop each day. 90 lots are now waiting to be issued as overdue. This represents about one day's delay.)

The purchasing representative must be specific in requiring that deliveries of materials neither precede the specified date or delay beyond such date. Some variation must of course be provided between the date of delivery to stock and date to send into process. This should be a standard time.

(*Example*: The present standard of stock time is ten days; i. e., if no more stock were received but issues continued per schedule, the stock would be entirely depleted in ten days, assuming that receipt and issues occur exactly to schedule. Practically, we have attained in late months an actual stock reduction to eleven and one-quarter days' supply without detrimental effect upon productive output or direct productive costs. Previous to new methods and present control plan, the stock investment represented a fifty days' supply. This automobile stock is evidently composed of a great variety of classes as well as characteristic parts. Some material is stocked for a complete schedule of six months or more up to three years for lumber. Such material is usually small in bulk, large in numbers and of relatively small value. Other material of appreciable bulk and value may be stocked to the short period of one week.)

From the above we conclude that control of stock has been obtained. Six principal items require control.

1. Requisition of material.
2. Placing of purchase order.
3. Securing of acknowledgments.
4. Receipt of invoice showing shipment of material.

5. Receipt of material into stock.
6. Issue of material to process.

PATTERN CONTROL

For castings, a pattern must accompany the requisition This, therefore, must be controlled. The principal items entering are:

1. Pattern order placed.
2. Work started.
3, 4, 5, etc. Percentage completed.
6. Delivery to foundry for test casting.
7. Casting received.
8. Issued to shops.
9, 10, etc. Percentage of casting tested.

11. Test completed, and if satisfactory, release the pattern to Purchasing Agent to ship to founder for production, or to local founder, from the local pattern control. If not satisfactory, recall the pattern and repeat.

CONTROL OF DIES FOR FORGINGS

This plan is similar to that for patterns. The control items are: (1) Order dies. (2) Secure and inspect lead proofs. (3) Release dies for test forgings. (4) Test out forgings to jigs or for hardness or chemical analysis. Release of dies for production.

SUPPLY CONTROL

Supplies for the shops are controlled under a budget plan. In recent years there has been accumulated a vast amount of information relative to the consumption of perishable supplies at the different classes of machines. This includes grinding wheels, polishing wheels, oils, waste, perishable tools, etc. From this accumulated information budgets are prepared for each department for each month and dates of deliveries of supply materials are controlled to agree with these budgets. While there may now be some variation, the increase of accumulated information will soon make it practically exact.

Supplies are despatched from the stock rooms sometimes with tools for the job, and at others to the workmen directly, as they come for jobs.

CONTROL OF MATERIAL WORK IN PROCESS OF PRODUCTION

This class of factory effort calls for the greatest activity on the part of the organization due to the many complex groups which enter. These principal groups are: (1) Buildings. (2) Machines and equipment. (3) Material. (4) Tools. (5) Men.

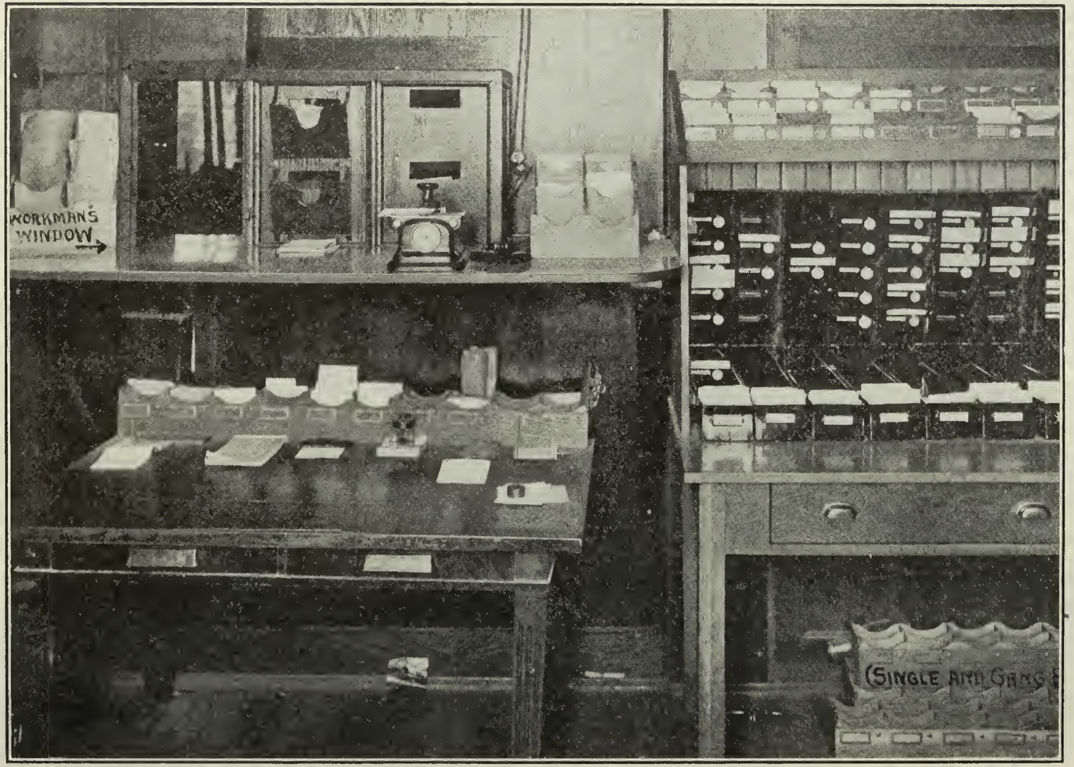
No group or subdivision of a group can remain in partial or without control and the final results be controlled. If the product is complex the least unbalance in the schedules of the groups will cause immediate congestion with a consequent temporary suspension of work in some divisions followed by a corresponding period of excessive activity. There will first be unemployment and later overemployment; idle plant and machines, with later a congested plant and machines. Delayed or limited material may be the cause of a greater congestion than material in advance of schedule. Either condition causes not only extreme dissatisfaction to all persons affected but it means large permanent investments in buildings and other fixed equipment for temporary use as well as unsalable material and labor.

A uniform burden on the works at the minimum investment is so desirable that all possible effort in this respect will be amply repaid if the classified plan of control is obtained and perpetually applied.

BUILDING CONTROL

The control of buildings for an ascending schedule is not difficult. Plans are laid as for materials and machines. All of the activities which are represented are analyzed and classified. Each class is further divided into its elements and the date for each element to start, proceed and finish is set. The setting of each date is made with reference to the date for the finish of the completed structure. The time for measurements, i. e., the time required to produce each element, is predetermined from exact knowledge and estimates. Promises of architects and contractors are not altogether satisfactory, since rarely do they have the opportunity to plan and supervise as intensely as is customary under the highly developed factory method.

The control of buildings for a descending schedule unless they can be sold for cost loss depreciation is never satisfactory. Some relief can be obtained by maintaining peak loads in outside rentals, never carrying a building equipment for probable peaks. The possibility of securing such outside



A substation from which one of the machine shops is controlled. The boxes shown in this photograph contain the time cards which have been written for the workmen and these time cards represent both the work they are actually engaged on and the work which will come to them next.

rental is a factor to be considered, for without it, it is either build or pass the business and the latter is not always the least objectionable.

(*Example*: Storage spaces for materials are constructed identically as for manufacture. As these spaces become occupied with manufacture, materials are crowded out into rentals until the permanency of this rental is evident, then new buildings are provided to house the permanent part of the overflow.)

CONTROL OF MACHINES AND EQUIPMENT

The fundamental of control of machines is the burden. "What machines" and "how many" for a given rate of output of a known product is a perplexing question. Expert mechanics of highly inventive ability in the planning room will specify the first part of this question, i. e., "What machines." The regulation of "how many" to produce a varying schedule of output can be secured through exact record of the time in which the machine can produce each operation on each piece which is routed over it. If the product is such a one or similar to that now considered, a burden record can be compiled to show each machine by number or symbol with all operation time routed to it for one unit of the finished product. The sum of such times for each machine multiplied by the number of product units to be made each day will give daily task. This daily task divided by the number of machines will give the daily burden. This burden divided by the number of time units in the standard day will show the number of machines required. Two essentials for the success of this plan are proper time allowance for machine breakdowns or idleness and exact knowledge of unit times for each operation. There is no way of securing this latter except by elemental time study. Since the machine operator's activity is a factor in the time taken by the machine, the operator must also accomplish his effort in the set time. This is prescribed in the instruction card with which the operator is provided. Regardless of the payment of a premium or bonus to the man for special attainments, it is absolutely essential for the welfare of his fellows, as well as the stability of the business, that the machine unit times be obtained and applied. Any delay on a part causes a delay of the assembly into which it goes with a consequent suspension of work of the assemblers. There will also come overdue shipments to the consumers.

The operations on parts which go over each machine having been recorded, from the schedule of the particular operation of that part which must be first worked upon, a date can be obtained for the delivery of the machine to its place on the work floor.

All machines planned for the same kind and quality of work are speeded, powered and made exactly alike in all mechanical respects. They are then classes in groups so that work routed to one can be placed with any of the others with certainty of predetermined standard performance. The group carries the group burden and in all respects acts as one machine. Each machine in the group is regularly inspected and repaired. Lubrication for cutting edges is controlled by a central equipment circulating to all places of use in the shops.

Example: Some of the groups and number of machines in each group as now arranged are:

Power mills, class 10, group of 4.
Power mills, class 24, group of 2.
Power mills, class 42, group of 3.
Hole grinders, class 11, group of 4.
Turret lathes, class 9, group of 8.
Polishing grinders, class 3, group of 12.
Drill presses, class 1, group of 6.
Gang drills, class 10, group of 6.

There is a considerable number of groups with from four to six machines in the group. The most difficult group is that of the turret lathes, class 9. Slight variation in the alignment of turret or spindle will eliminate the machine from the group.

With a larger productive output the number of machines in each group would grow practically proportional to the output.

CONTROL OF MATERIALS

No plans for control of materials over the varied paths in the works can be successful unless controls previously mentioned have been established and are perpetually maintained. Even with this satisfactory maintenance under the usual plans the detail in this effort is enormous. For exact control—and this is so much more satisfactory than that which is approximate—each activity on each part and assembly must be specified. One chief essential, but one seldom practiced, is the determination and standardization of lot sizes for each part. These lots will be moved from station to station on the routes as units, each lot to remain at each station until the work specified to be done at the station is completed on each piece in the lot. Without exceptional orders, once the work at a station has been started on a lot of one part, until it is finished no other lot of another part can be started. This precludes the use of stock chasers or other local shop authority since they are not in a position to judge the relative importance of delayed parts as against other work waiting at the machine when the delayed part reaches it.

Under a standard lot size plan the variations in quantity of output are obtained by corresponding variations in the frequency of despatching individual lots.

(*Example*: Assume a standard lot of finished product at Final Assembly to be 50 units, and the schedule to require 10 units per work day. Then lots of parts for final assembly will be despatched from finished stock each 5 work days. If a product part, one of which is used in each unit of the finished product, is moved in lots of 500 pieces, this quantity will satisfy the assembly for 50 work days and will be despatched from raw materials stock at that frequency. The same frequency will obtain at each station on the route. If each assembly lot is 25 days in process, then 5 lots will be in process at all times. If the lot is in process 15 days, then 3 lots will be in process at all times.)

Since the same kind of machine work will occur on many different parts, the order of approach of the parts to the machine must be controlled. The parts must be moved to the machines and be recorded at the machine before the work order is given to the operator. If machines are grouped the material must be delivered to the location of the group and this recorded as received. The first free operator in the group must then be given the part next due. This action is readily secured by dating each operation job card at the Control Board, which insures accurate relative order of work. The jobs for a given group of machines are arranged in a machine job card box in the order of these datings. Despatch boys local to the shops are held strictly accountable for the giving out of jobs to the operators in the order of dates. Any job not issued by a given hour, on the day specified is marked with a "Lot Urgent" card. This card is signed by a superior in the Planning Department, and upon this signature becomes a standing order to the superintendent and foreman to provide overtime or night work for the job. If any one part becomes overdue with aggravating frequency, or if a machine or group of machines is constantly marked with urgent cards, the Routing Division is called into consultation to advise a solution.

At the present time there are 12,000 jobs standing in the machine racks. There are an average of 600 jobs started per day. There are 450 urgent tags standing; i. e., one day's extra activity of the working force would bring all work in the shop up to schedule.

The variations in hour's work on overtime or night shift is slight. We conclude from this and from the fact that final product follows its schedule exactly, that average errors in operation are constant.

We also conclude that if no urgent tags stood against work, that the investment in work in process account would be excessive, i. e., we would be ahead of schedule on produced parts, which product would remain in an unassembled state lacking finished purchased parts for its completion.

Scheduling of standard lots, coupled with sure methods of despatching over well planned routes should obtain most beneficial results from the reduction of investment charge as well as the delivery of salable product.

These are two of the most important accomplishments in factory conduct. Known time elements are fundamental for this conduct. When known they must be obtained regularly in practice.

(*Example*: Previous to the control of our factory work by the above plan, the work in process investment account represented three and one-half cars for each car produced per month. Now it is one and one-tenth cars for each car produced per month; i. e., we turn our money over three times as fast as before.)

CONTROL OF TOOLS

Coincident with the routing of operations to machines is the specification of tools. These include jigs, templates, gauges, drills, taps, dies, wrenches, and the forms and sizes of all cutting edges. The date of tools due in tool rooms is specified and the minimum quantity to carry entered on the tool ledgers. The stock is maintained thereafter by the tool ledger requisition.

As each job comes up to a machine the tools are ordered out to agree with the tool list for the operation. These are delivered to the point of use, a signed receipt therefor by the floor executive, delivered to the despatch clerk releases the job if the receipt for material has been filed.

After tools are used they are returned to the tool stock for inspection, shaping of cutting edges and such repairs as are deemed necessary.

CONTROL OF MEN

Where large quantities of the same part are made or where the limited performance of a special machine is continuous, men are naturally employed steadily on limited work. This limited work is not a function of a particular kind of plan, but rather an economic specialization as is true in all branches of industrial activity from the engineer on a limited train to the farmer at his plow. The miles to go or the acres in the field limit the time of change of application of effort.

A complete knowledge of what is to be done and this taught to the workmen by written instruction allows quite unskilled men to become useful productive units. So many men and their work are misfits and employing men for what they can learn to do and not for what they know makes rather easy the task of the employment agent. Employment centered in a representative of the chief factory executive, and discharge possible only upon the written approval of this executive secures steady permanent workmen. Wages sufficient to interest them in outside investments, work hours which allow them time to supervise and enjoy such investment, permanency of employment assuring the continuity of this enjoyment aid materially to stabilize the force and assure a steady high grade output with much happiness in the working hours.

(*Example*: Of the force now employed, 20% are over 50 years of age; 5% over 60. The average age is 37. The average period of last employment for the whole force is four years; for one-half the force selected, six years. It is evident from this that the labor turnover is very slight.)

CONTROL OF MONEY

The index of successful industrial operation which makes comparable various kinds of work and various kinds of control of the same is, "money." I have indicated in this connection the effect of this work on investment charges. I wish to mention briefly the effects upon other prominent factors. The sale price of an improved product has been decreased 30%, caused by corresponding decrease in the costs. The average monthly earning of labor has increased 28% and is still rising. Supervising, or indirect costs, have decreased in the same proportion as direct labor costs.

The control of money spent for indirect purposes is obtained through a supervisor and estimator, who, working from accumulated data, contracts, bids, etc., is able to specify very closely the cost of a given job. After proper approvals and the work is finished, the frequent checks against the work in process and the final result are referred again to the estimate and the experience so gained is applied to the next work of a similar kind.

CONCLUSION: It has not been the writer's intent to tell you all that can be told about the subject of intensive control of manufacturing work, but rather to indicate the elements which enter into such intensive control.

We have had many visitors to our works from nearby cities and there may be some among the readers of the Purdue Engineering Review, some whom it has been our pleasure to entertain. They can bear me out in the statement that many days could be spent over the details which enter this problem and then perhaps not clearly analyze the solution which we have made as compared to their own problem.

Time, as has been mentioned, is such an essential in the carrying on of a complex business, that regardless of all of the activities of persons hostile to time study, they will never stem the tide of the flood of effort and thought toward a solution of this problem in which fact will supplant opinion, and true knowledge will eliminate the fear which now leads to any organized opposition. Premium or bonus methods of payment are not essential in any plan of Scientific Management if anything can be substituted therefor which will cause a task set by known facts to be carried out regularly.

I feel that the industrial world is greatly in debt to Dr. Taylor and his associates who have assisted in the promulgation of these principles, and although the way in which they may have been presented may not appeal to some persons, the experiences of industries which have tried conscientiously to carry out the principles without change will sustain the truth of the statements which have been made with respect to them.

Detail of Control Board.

THE OPERATION OF THE CONTROL BOARD

By M. J. GOLDEN*

Synopsis: Supplementing the explanation of the control boards illustrated in the preceding article.

George D. Babcock, of the class of 1904, now Superintendent of Production of the H. H. Franklin Mfg. Company, of Syracuse, N. Y., has developed a method of inspection of his Production Department that is unique and exceedingly interesting; a scheme by which he tells just the condition of any given order at a glance. A good idea of the method can be obtained by a description of its actual operation on an order at the time of the writer's inspection of the system.

An order for 400 machines had just come in from Detroit. This order was divided into groups with 17 machines in each group, as 17 machines could be carried on simultaneously with the apparatus that was available in the shops.

A board of about 4 feet x 12 feet was prepared in such way that small blocks of wood one-half inch square could be attached to the face of the board. In examining the details of construction, the particular piece that took the greatest amount of time was placed on the board by its number and letter at one extremity of the board and then each piece that went to make up the total machine, placed on the board at the time when this piece must be started to have it fit in with the construction of that particular group of machines.

It was found for illustration that the greatest amount of time was taken by one of the small pieces that went to make up the steering post. Then this piece was placed at one extremity of the board and the other pieces that went to make up the machine were placed each in its proper place on the board, the total board representing the time from the starting of the machine to the time when it is delivered on the floor.

Now the board is divided into time units. Fifteen units are taken for the unit of division. An inspection of the board will show when each piece of the machine ought to be completed to within this limit of fifteen minutes. If at the end of, say, four days, the pieces that ought to be completed at that time are not completed and properly delivered, an inspection of the board will show that fact, as on the completion of any given piece, its letter and number are taken from the board at once.

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Now in the orderly procession of this group through the shop, if any one piece falls behind, an inspection of the board will show that fact at once because the block containing its distinctive mark is still on the board, whereas if the work is going along properly, the number back of the given date ought to be empty. If a piece does fall behind, provision is made for it by putting it in as night work until it is brought up to its proper time.

Now, of course, the particular feature of this scheme is that a glance at the board will tell the story at once as to whether or not any particular order is coming along as it should.

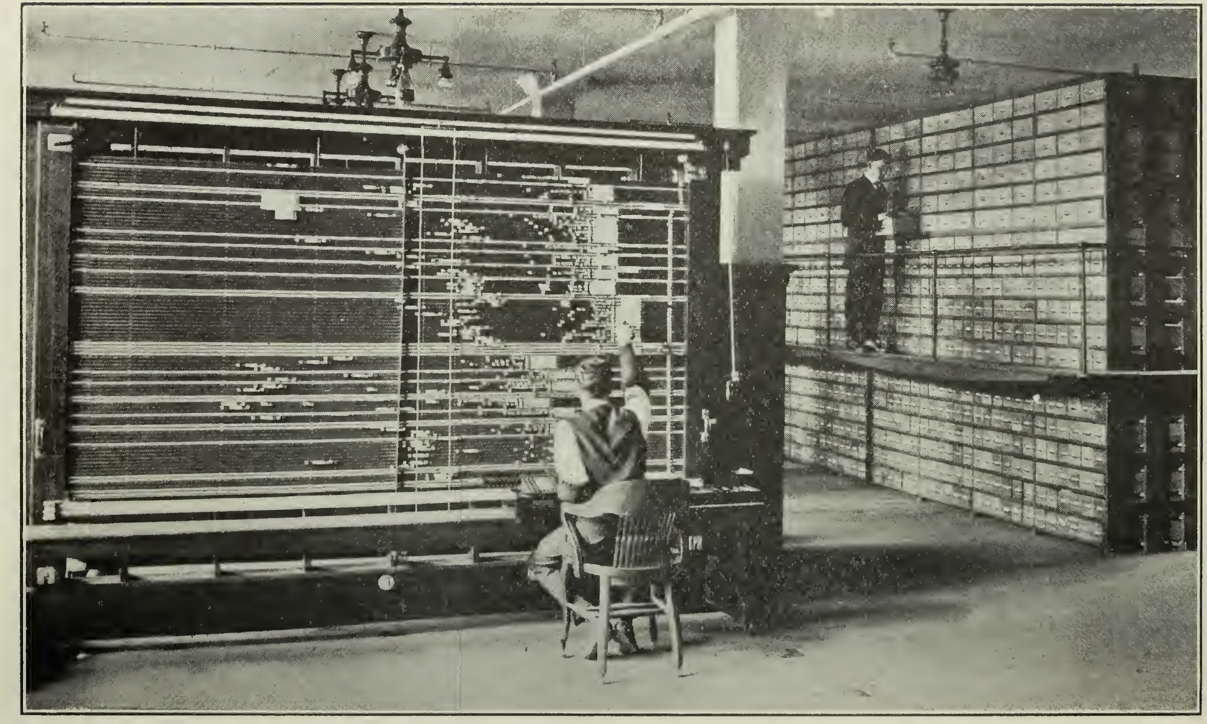
At a time when a boy who has not any great degree of skill starts to arrange the details on this board, there is started in the order department a full set of order cards and other necessary instruction, and reports that go with this particular group in its progress through the shop so that before the work is started in the shop there is prepared an inspection board and a complete set of orders and instruction cards, and every detail of the work is anticipated.

As against one thousand workmen employed in the shop in the production department, there is a clerical force slightly in excess of one hundred employed in filling out order blanks and other cards that go with the particular group in hand.

An idea of the success of this method may be had from these incidents: a group of machines that had been in process of construction during seven days was found to have three small items that had dropped behind, and an inspection of the number for that particular group showed this fact at once, so that the manager was able to provide for those three pieces as night work and have no interruption in the work later at the time of assembly.

As an incident of this method of handling work, a line of maximum production with the use of the apparatus that is available in the factory is established after considerable experiment, and the effort with each group is to approach this line.

Mr. Babcock assured me that except as he introduces new schemes in the shops, though production manager, he is, under this system, one of the least busy persons in the establishment, and an inspection of the scheme will develop at once why this is so.



(From *Iron Age*)

To be able to purchase material so that it is ready at the logical time for machining or assembling or both and still maintain the most economical investment of capital; to be able to issue such as is machined to the shop at the proper time and in most economical lot sizes; to finish the parts in the shortest time consistent with good workmanship, and finally to deliver all parts to the assembly floor and insure the completion of the finished car, is with the H. H. Franklin Mfg. Company taken care of to a great extent by the Taylor system of scientific management and the control boards shown are used.

A motor car consists of, say, two parts; the vehicle and the power plant or engine in the vehicle. Taking the engine and carrying the process of division further, it will be seen that the engine consists of several groups of parts which may be called divisions; these divisions in turn comprise groups which may be called sections; the sections are combinations of still smaller groups which may be called sub-sections, and so on down to the individual pieces. To illustrate, the carburetor constitutes something which may be assembled complete and attached to the otherwise complete engine. The carburetor division may consist of three or four sections which together with individual parts are assembled and constitute the complete carburetor.

The boards themselves are large frames containing a great number of horizontal strips. Across the top of each frame is an adjustable scale. Sliding up and down the frame parallel with the strips is a cross piece, or runner, also having adjustable scales in it.

Each horizontal strip has fastened to it several blocks. A small number of the strips are white in color, while the majority are black. Each black strip represents one part required in a finished car, while each white strip represents an assembly of the parts on the black strips immediately above it. Each of these assemblies forms one of the sub-divisions, sections or divisions, previously mentioned.

Taking any one black strip, it is noted that there are several blocks attached to it at different intervals along its length. These blocks represent each operation of a finished piece from the time of purchase to the time of its completion ready for use in assembling the car. The longer blocks at the left hand side represent the requisition for the purchase of the material for the part, the smaller blocks along the strip represent each step in the process of the part and the long strips at the right hand end represent the finished part. The spacing of these blocks and the length of the blocks themselves, is to a predetermined scale, and bears a fixed relation to the top scale and sliding scales previously mentioned. By means of numbers on the blocks themselves and the values of these numbers as compared to the numbers immediately above them on the top scale, the information is given as to whether a part is behind or ahead of schedule.

SHOP CONTROL

By L. W. Wallace*

Synopsis: Showing how the principles of Scientific Management have been successfully applied by the H. H. Franklin Mfg. Co. to their automobile repair shop thereby refuting the statement that this modern idea in management cannot be applied to industries with many variables.

At the suggestion of the editors the following remarks are submitted concerning the shop control methods of the H. H. Franklin Mfg. Company. This discussion is based upon observations made at the Franklin plant in Syracuse, upon a number of conversations with Mr. Babcock, and by the information obtained through a very careful study of all that Mr. Babcock has written upon the subject of shop control.

Before entering upon a discussion of the subject the writer wishes to congratulate the Review Editors upon securing such a timely article from one so eminently qualified to write it. Mr. Babcock is generally recognized as one of the most prominent production managers who is practicing the new thought in management. The plant over which he has control employs more men than any other plant operating under Scientific Management. This adds emphasis to any statements that Mr. Babcock may make concerning modern methods of shop control. The achievements of Mr. Babcock have been noteworthy. His work has been constructive and unique. His control boards are marvels of conception and of execution. They can be fully appreciated only through a careful study and observation of them. Professor Golden has indicated some of their significant points. This discussion is not concerned with the control boards, however, but more particularly with the methods used in the Automobile Repair Shops of the Franklin Company.

Many have made the statement that Scientific Management may be all right for an industry of uniform product, quality and quantity, but that it will not apply in an industry when there are many variables. This statement has been disproven by actual practice in the plant of the H. H. Franklin Mfg. Co., for in that plant three separate and distinct lines of activities are conducted:

One: Motor car manufacture, of fairly uniform standards and requirements as to design, material and quantity.

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In the second case the manufacture of supply parts, for repairs, which parts are subjected to fluctuating demands; the demand varying both in quantity and pattern.

Thirdly, an automobile repair shop, where the demand is much more varied than in either of the other two lines of activity. It is questionable whether there could be an industry more variable in its several aspects than in the making of repairs to automobiles. If in the presence of so many variables such standards and methods can be adopted as to facilitate deliveries according to promise and at the same time reduce the cost, then indeed it may be said that the principles of Scientific Management are applicable to almost any industry.

To apply the principles of Scientific Management to an automobile repair shop certain things must be done; certain facts must be established. One of the first things to be done is to find out what the shop can do, what the facilities are and what the capabilities of the workmen are.

The second step is to find out what is to be done, and to determine the relationship between the several operations or processes.

The third step is to classify the jobs, the workmen and to perfect the organization and methods.

To determine what the facilities are is not a difficult task, inasmuch as an automobile repair shop does not require a large assortment of physical equipment. Neither is it essential or feasible to establish a complete or satisfactory machine burden in a repair shop of this character. Hence the question of physical equipment does not require a great deal of attention. But in such a shop the human equipment becomes of prime importance. Hence to know what that element of the shop facilities is capable of doing is an important step. In the Franklin shop this was arrived at by securing a written statement, from each employee in the repair shop, of what he could do. By this means the qualifications of each man became known. The men were then classified into groups as A, B. and C. This grouping was according to their ability. If it was found that a man over-estimated or over-stated his qualifications he was penalized by being reduced two grades. If on the other hand it was found that he could do work in an upper grade, and that 50% of his time was spent on such work, he was then promoted to the higher grade.

According to the classification used each man was capable of doing all the work in his grade and also all the work in the grades below him. He was paid the rate of his highest grade, however. An effort is made to keep a man busy in his class, for that is the work for which he is best fitted. Also the higher the grade the better the class of work assigned. There is a constant incentive, therefore, for the men to want to be graded higher, because of the higher pay, more agreeable work and additional prestige. On the other hand, there is a motive for the employer to raise the grade of the workmen, because it makes a more flexible labor condition and more contented and happy workmen. Through this classification of labor the men are required to work on jobs for which they are best fitted; they are encouraged to push forward and are rewarded for accomplishment.

To find out what was to be done was accomplished by conferences. In these conferences the foremen, the works manager, and the superintendent gave their opinions. At first the conclusions and suggestions were very divergent, but as time passed a standard was arrived at by which each operation was classified and a standard time set, the standard time being established, largely, upon record of past performance. Having the men and the jobs classified and the time required for each operation it then become an easy matter to work out certain standard methods of procedure.

The work was classified into nine general classes, as follows:

A. Foremanship and inspection.
D. Road jobs.
G. Tune up and road tests.
K. Overhauling.
M. Light repairs.
P. Electrical work.
S. Body and accessories
V. Stripping.
X. Washing.

The arrangement of the classes of work was in the order of the ability and training of the workmen. A workman who could do Class A work was also capable of doing all the work required in the classes below A and likewise for each class of workmen. This being standardized, a despatch boy could give out work to men as they came to the window, knowing to what class each man belonged.

For each elemental operation of each class of work, detailed instructions were prepared as to how to proceed, as to tools required and as to materials and parts involved. The part numbers are shown on the instruction card, so the workman loses no time in instructing the material boy as to what is required.

In the preparation of the instruction cards the men, that is, the workmen, are encouraged to give suggestions. In fact many of the instruction cards have been prepared by the workmen at their homes at night and at off hours. For such work the company pays them liberally. Complete and detailed records have been kept from the beginning of the new order of things. Through the study and analysis of this information improvements are being made constantly.

With the organization perfected as outlined, a customer drives in. The superintendent, with an inspector and the owner makes an inspection of the car and agree upon what is to be done. The superintendent makes out a route sheet which shows the customer's name and order number, estimated date and hour of delivery and a statement, in paragraphs with symbols, of each element of the job. According to the standard classification, this route sheet becomes an agreement as to what is to be done and it is also a work order for the job. The owner is given a copy or one is mailed to him promptly. No work is done on the car that is not specified on the route sheet, until the owner's consent is obtained.

As the superintendent made out the route sheet he noted on the margin the required time for each elemental operation and the allowance time between each operation. With the date of delivery set, the time to begin work on each elemental operation could be set, even to the hour, in order to have the car ready for delivery at the time specified.

The route sheet was then sent to the planning room, where the Route File Clerk immediately translated the order and wrote a job card for each operation and symbolized it according to the standard classification. The job card consisted of three copies; the face copy being a small coupon; the second copy an inspector's and move ticket; and the third a workman's job card.

The job cards were then put in boxes in the despatch racks, especially arranged as follows:

A special box was prepared for each class of work. This box had two compartments. In the front compartment were placed all job cards for the jobs ready to be done. In the back compartment were placed the job cards that were written but jobs that were not ready to be worked upon. In the cover of each box was a compartment for the name of each man enlisted in that class of work. The arrangement of the names of the men in these compartments was in the order of their ability.

After the job cards were written they were given to a despatch clerk who placed them in the correct compartments. As a man completed a job he would turn in his job card. The clerk, knowing to which class of work he was assigned, handed the workman the first job card in the box of his class. As the job cards were arranged strictly according to date, the job card of the job needing the most immediate attention would be given out. If there was no work to be done in the class to which the workman belonged he would then be given the first card in the next lower class. The despatch clerk would not have to seek authority for this as that is a standing rule and practice.

If on the other hand a job was urgent, that is, behind schedule or the owner was waiting, then an urgent tag would go on, which would mean that the man who was ringing in on one job would be assigned this urgent job, although it was in a class below his own, and notwithstanding any orders that might be ready in his own class. Indeed, an urgent tag always implies that immediate steps must be taken to start some one to work on that job. This may mean the causing of a man to ring in on an assigned job before completed and take up the urgent one. By this system the schedule is maintained and the cars are delivered according to date and hour promised.

An hourly inspection is made of the bulletin board. By this inspection any orders behind schedule are discovered and an urgent tag is attached. At four o'clock each day the jobs to be worked upon are inspected as to dates. If any of importance are behind schedule an urgent card is placed upon them. The bulletin board is marked to correspond and curves are plotted which show to the superintendent the condition of orders. By the indications of these curves he is enabled to better schedule the work.

As a result of the methods briefly discussed, many advantages have occurred:

The superintendent has time in which to meet customers and to deal with them with satisfaction.

The workmen are assigned work for which they are best qualified. There is little time occupied in determining what is to be done and in getting it done.

The customer is not annoyed by not getting his car when promised, as the schedule is lived up to in about 90 per cent. of the cases and this percentage is increasing.

The workmen are encouraged to reach higher standards and to become fitted to do a better grade of work.

The cost of repairs has been reduced.

The demands upon the shop have become more uniformly distributed throughout the day and the year. A special repair price of 30 per cent. reduction is given on all repairs made in winter months, that period when motor service is least.

These and other satisfactory results have been obtained, which serve to demonstrate that the principles of Scientific Management can be successfully applied to a shop where many variables prevail.

Campus View Purdue University.
Practical Mechanics Building in background.

WHITE SUGAR—CANE OR BEET?

By Albert Hugh Bryan, '98.*

Synopsis: This paper presents the reasons advanced by one of the leading authorities on the sugar industry in this country, why beet sugar will produce as satisfactory results as those obtained from the use of cane sugar. For those readers who have been under the impression that the beet sugar is not as sweet, that it prevents the jellying of fruits, that it produces discolored "fondant," and is generally inferior to cane sugar, this article should produce a changed viewpoint.

To the layman, sugar means white granulated sugar, while to the chemist it also signifies the sugar, sucrose, which is the predominant sugar in ordinary white sugar. Common usage, covering many years, has added the word "cane" to the word "sugar" from the fact that the tropical or semi-tropical sugar cane produced all of the sugar of commerce. In later years the words "Cane Sugar" have been applied also to the white sugar produced from sugar beets, since the two products seemed identical.

Today it is an open question whether the terming of beet white sugar as cane sugar is correct; especially is this so when one considers that white sugar from beets is quoted at from 10 to 20 cents per 100 pounds less than that made from sugar cane, and also in view of the fact that many users of beet sugar claim that it is inferior to cane sugar. This, however, is a question of labelling under the various pure food acts.

The various views held regarding beet and cane by users of sugar are interesting and I desire to present a few of these, trying to show their relations to the product.

Chemically considered, white sugar from these two sources contains practically the same percentage of sucrose, viz., 99.5% to 99.8%; the same percentage of moisture, viz., .05% to .20%; the same percentage of mineral matter, viz., .05% to .20%, and the same percentage of undetermined matter, viz., .05% to .20%. Then it would be reasonable to believe that they have the same sweetness. However, there are persons who claim that beet sugars are less sweet than cane sugars. The sweetness of a product is due to the substance itself and also to the quickness of solution in the mouth. The ease of solution is regulated to a great extent by the hardness of the crystals of the sugar. A manufacturer can easily regulate the temperature of "graining" and finishing, thereby producing a hard or comparatively soft crystal, so one can reason back that beet white sugar and cane white sugar of the same degree of purity should not differ in sweetness.

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As regards color of the sugar, some claim they can distinguish one from the other by this means. At the start of the beet sugar industry, the policy seemed to be to produce a sugar that would be merchantable with no idea of standardizing the color, grain, etc. As a result it became popular practice to "blue" the sugar so as to make a marketable white sugar. In doing this, many times the product was so heavily "blued" that on solution in water the insoluble blue (ultramarine) came to the surface as a scum. This then led users to claim that beet sugar was always heavily blued and thus inferior. Partly on account of this trouble, and also on account of food laws, the practice of blueing of sugar, especially in such noticeable quantities, was stopped. Today when blue is used, it is in very small percentages. Users of blue claim that a dead white sugar is livened by blue and it does not conceal any inferiority in the product; hence they argue for its use. In a general way, the color of a sugar is regulated by the size, evenness and clearness of the crystals. All of these can be regulated in the boiling of a sugar, so one would not expect to find any striking differences between white sugar from these two sources.

Another contention of users of sugar, especially among makers of jellies, marmalades, etc., which seems to have little weight, is this: that beet sugar prevents the jellying of fruits, also with its use there is a larger percentage of loss by fermentation in the finished products. The jellying properties of a fruit juice are due practically wholly to its pectin content. If this is not sufficient or if the bodies forming this general class are not correct ones, no fruit juice will congeal. Commercial manufacturers often treat fruit juice with phosphoric acid or some other acid to change these pectin bodies into the proper form or condition to produce a jelly. Sugar seems to play no part in this system. As regards fermentation, if a certain sugar produces a fermentation in fruit, this evidently is due to contamination of the sugar after it leaves the factory and is not an inherent quality of the sugar, for in the course of manufacture of the two products the temperature, which is high, is practically the same in beet and cane work. The other point often made in this connection, viz., that with beet sugar the finished jelly or preserves will show more crystallization of sugar than when cane sugar is used, may or may not have weight. Crystallization in the finished product is due to a supersaturation of sugar. This supersaturation is just as liable to occur with beet as with cane sugar if too much sugar has been used. If, however, the fruit juice was acidic, thus causing a slight inversion or breaking down to the simple sugars, dextrose and levulose, during the boiling, the use of one lot of sugar might show crystals in the finished product more than with another lot, due to the neutralization or partial neutralization of the acid by the salts or ash in the sugar. That the quantity of ash does influence the results is evidenced when making commercial invert sugar by heating sugar with a very small percentage of acid, in that certain sugars take much more acid than others to produce the same degree of inversion with the same heat in the same time. For inversion processes, then, a variation in the content and kind of ash may play an important part in the manufacturing of a product. One, however, seldom considers the ash content of white sugars as an important determination. As to whether or not beet sugars contain, as a rule, more ash than cane and hence are not interchangeable in these manufacturing processes, no one can say off hand, as there are not sufficient results available.

The candy maker is often heard to say that he cannot use beet sugar in making "fondant" or hard white candies for the reason that the product is always colored, generally yellow or brown. This darkening, which is evidently produced by the heat necessary for concentration, is due to the class of substances we speak of as undetermined in our general analysis. This condition may also result when using cane sugar, for experimental work has shown that some lots of cane white sugars will also produce dark colored white candies. The candy maker, then, who desires white candies has either to try out experimentally the various lots of sugar that he buys or obtain certain grades for his work.

These impurities make themselves felt, or are the reason for the excessive foaming, when bringing large batches of sugar into solution in water and they cause the varying quantities and qualities of the scum noted when using varying lots of sugar. The cloudy appearance of a clear sugar syrup after standing some time is also due to these impurities. And again, certain of these unestimated impurities may be the cause of the bleaching of the delicately colored fruit when preserved in sugar syrup, which is more noticeable at one time than at another. Whether these conditions are greater when using white beet sugar than when using cane sugars needs further careful demonstration.

These considerations, however, should open a new field of research which might lead to a more careful sugar manufacture and to a more careful and extensive examination by the chemist of the individual lots of sugar.

In closing, there is one point in this contention that often goes unchallenged, viz., that beet sugar abroad is used almost wholly for all purposes without any of these troubles. Hence, American beet sugar should do the same. In the United States beet sugar is made direct from the sugar beet with a single crystallization, while abroad *raw* sugar is made direct from the beet and this is dissolved, treated in the refining process, then crystallized; hence, it is the product of a second crystallization. Second crystallization should yield a purer product. It may or may not, but it does give a different composition of impurities in that class of undetermined matter which the chemist of today seldom investigates. The American cane sugar today is, with the exception of a small amount produced in Louisiana, the result of a double crystallization or has been made into raw sugar and then refined.

COASTING RECORDERS FOR CHECKING ELECTRIC CAR OPERATION EFFICIENCY

By C. C. Chappelle*

Synopsis: Explaining how Coasting Recorders for checking electric car operating efficiency have brought about net savings of from $50.00 to $200.00 per year, and how the most efficient car speed as well as the motorman's pay time is obtained from the Coasting Recorder card.

The analysis of the fundamental principles† involved in operating any given car and its equipment, of given gear ratio, under given conditions, establishes the following:

(a) Efficiency in the operation of a given electric car and its given equipment is solely dependent upon the efficient utilization of certain controlling time-element factors.

(b) The efficient utilization of these time-element factors is measured by the coasting time and the per cent. coasting, for the varying conditions encountered in practical operations.

(c) For any existing or adopted schedule speed, on any electric railway, increase in the coasting time means increase in efficiency and a schedule speed to be economical must permit of possible coasting time.

(d) For a given car and its equipment, there is a most economical schedule speed, dependent upon traffic conditions and the relative unit costs for power and platform labor expenses; such economical schedule speed has a corresponding resultant per cent. coasting; if the schedule speed approaches the economical schedule speed for the traffic conditions, the corresponding resultant per cent. coasting shows relatively slight variations for the ranges of traffic conditions usually encountered in practical operations.

From the foregoing it is apparent that the per cent. coasting, determined by measuring the coasting time, is the correct relative measure of efficiency in car operation under conditions encountered in practice and that the per cent. coasting is the proper basis for a correct method efficiency checking system.

The Rico Coasting Recorder (Fig. 1) is essentially a clock mechanism of simple and rugged design, so constructed and connected by suitable electric relay with the car wiring and brake equipment as to measure and print the time during which the car is in motion with "power off" and "brakes off," or in other words the coasting time. From the coasting time the per cent. coasting, i. e., the ratio of the schedule time to the coasting time is determined. The Rico Coasting Recorder, therefore, meets the requisites for a correct efficiency checking system.

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† For the analysis of these principles, the reader is referred to an article, by the author, in the Electric Railway Journal, Jan. 15, 1916, entitled—"Fundamental Principles of Car Operation Efficiency."

The results obtainable in practical operations by the Rico Coasting Recorder utilized as an efficiency checking system may be summarized as follows:

I. EFFECT ON POWER:

1. A saving in power consumption; the percentage of saving in power being approximately directly proportional to the increased percentage of coasting. (See Table I.)

2. A lowering of the peak on the power station.
    a. Due to the decrease in average power consumption per car per hour of operation.
    b. Due to the motorman's time in accelerating the car becoming more uniform and approximating the calculated acceleration time, based on the motor equipment characteristic performance for the established schedule speed and traffic conditions.

II. EFFECT ON BRAKE SHOE MAINTENANCE:

Due to saving in direct brake shoe wear. As the energy to be dissipated in brakes varies as the square of the speed at the time of applying the brakes, therefore, as a portion of the energy stored in the car is utilized in coasting, the speed at the time of applying the brakes is less, with a resultant reduction in the energy to be dissipated by the brakes.

III. EFFECT ON EQUIPMENT:

1. Decrease of armature and other motor troubles due to smaller rise in temperature, resulting from lower average amperes passing through the motor.
2. Decrease in wear and tear on equipment in general, resulting also in saving in maintenance and renewals of wheels, gears, etc.

IV. EFFECT ON RUNNING TIME:

The regular running time is made more uniform per trip and closely approximates the schedule running time, due to the system of checking by the use of the Rico Coasting Recorders.

V. EFFECT ON ACCIDENTS:

Decrease of accident liability.

a. Due to lowering of maximum attained speed, hence resulting in more uniform speed.

b. Due to more uniform braking.

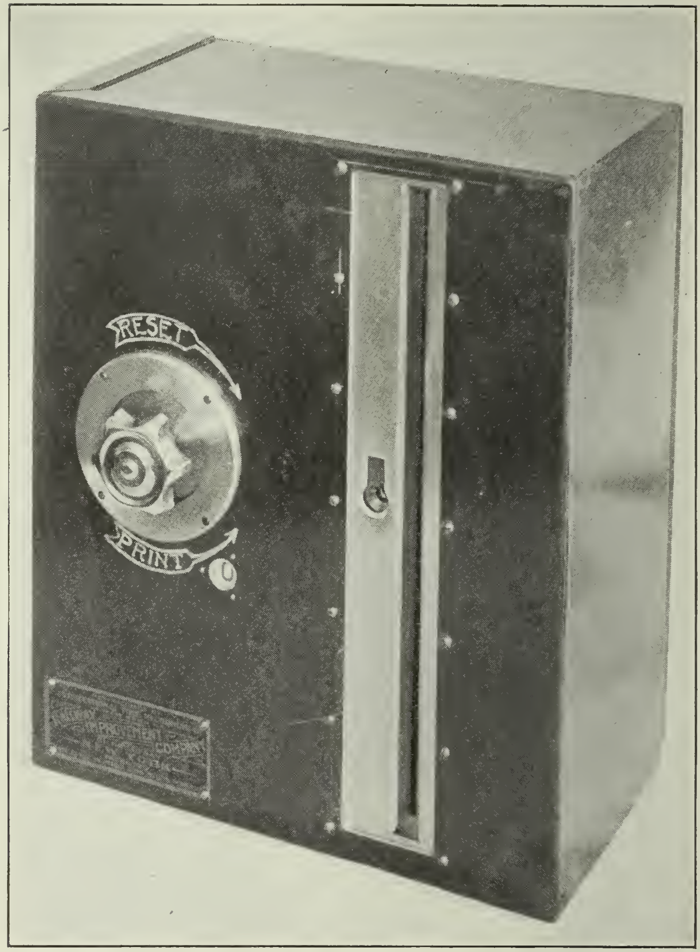


Fig. 2.

c. Due to power being on a smaller percentage of the time, thus leading to one less operation to stop or reverse the car as necessity may demand.

d. A motorman to obtain maximum coasting time must at all times be on the alert to avail himself of all opportunities; therefore, as a natural deduction the motorman ceases to be an automaton. He becomes a thinking operator on the alert at all times. Hence under these conditions accidents to pedestrians and traffic vehicles will diminish.

The consideration of the principles involved in the attainment of car operation efficiency shows that all the time-element factors, determining and controlling efficiency are not within the control of the motorman. For illustration, the motorman has only part participation in the resultant duration of stops, and the schedule speed and number of stops are wholly determined by others and by the traffic conditions.

The attainment of possible efficiencies in car operation means in practice not only improvement in the efficiency of the motorman, for any existing schedule speeds and traffic conditions, but also means the accomplishment of additional attainable efficiencies through economical schedule speeds based on the analysis of the accurate record of traffic conditions for each hour and minute of each car on every line or route of a railway system.

The Rico Coasting and Service Recorder (designated for commercial abbreviation Rico C. & S. Recorder) is a recent development, based on the essential features of the Rico Coasting Recorder, modified in design to give in printed card form the essential factors encountered in practical operations effecting car operation efficiency. Figs. II, III and IV show respectively exterior and interior views and facsimile of record, of the Rico C. & S. Recorder.

Referring to Fig. IV, from left to right, the form card record shows for each trip of a run or between any designated points for which the information is desired, the following:

Column S. The record of the total number of stops.
Column S. T. The record of the aggregate total time in minutes consumed by the total number of stops.
Column C. T. The coasting time in minutes.
Column R. T. The actual total running time in minutes, including in such total the aggregate stopping time. (Column S. T.)
Column Badge No. The badge number of the motorman operating the car when the record was obtained.
Column Car No. The number of the car on which the record was taken.
Column Trip No., at the extreme right, is self-explanatory. It acts as a guide and gage to the motorman for placing the records consecutively on the form card.

The columns S., S. T., C. T. and R. T. are totaled for the motorman's daily operation and entered as indicated.

The form card can be arranged with space at the bottom, as shown in Fig. IV, for entry by the time clerk of the motorman's pay time, for the day. This entry can be made by the time clerk, or by an automatic time clock, showing the day of the month and the motorman's exact time on and off duty, leaving only the footing of his automatic record of pay time to be entered by the time clerk, as shown on Fig. IV. This particular motorman's total pay time for November 25, 1915, was 580 minutes or 9 hours and 40 minutes for the day.

The Rico C. & S. Recorder, it is apparent, possesses all the advantages and results obtainable from the Rico Coasting Recorder, but it also makes available for utilization in the determination of economical schedule speeds and for analysis of the equities of standards for service, the constant, accurate and automatic record of the vital factors of varying traffic conditions.

The operations required to obtain the record are quickly made and "fool-proof." In making the record, all the type dials return to zero position for each dial after making each trip or desired period record, thus facilitating the clerical work required in making any desired footings for analysis. As the record is on a card, it is more convenient for handling, reference and preservation than the tape form record used in the Rico Coasting Recorder.

With the Rico C. & S. Recorder record available, the correct measure of the motorman's efficiency is not only shown by his per cent. coasting, but the data are available to check his actual efficiency with the obtainable efficiency for the schedule speed under the recorded traffic condition factors.

The Rico C. & S. Recorder removes the construction of economical schedule speeds from the realm of experimental determination and guess-work, as the data are available for the schedule builder to determine the economical schedule speeds which will fit the available equipment for the actual traffic conditions.

The Rico C. & S. Recorder records make available the data for determination of the suitability of the gear ratio of the equipment from the record of the traffic condition requirements.

The records of the number of stops and duration of stops, in connection with the passenger record data, can be utilized to determine the efficiency in practical operations of entrance-door designs, step heights, seating arrangements, etc., thus giving definite data for determining their adoption.

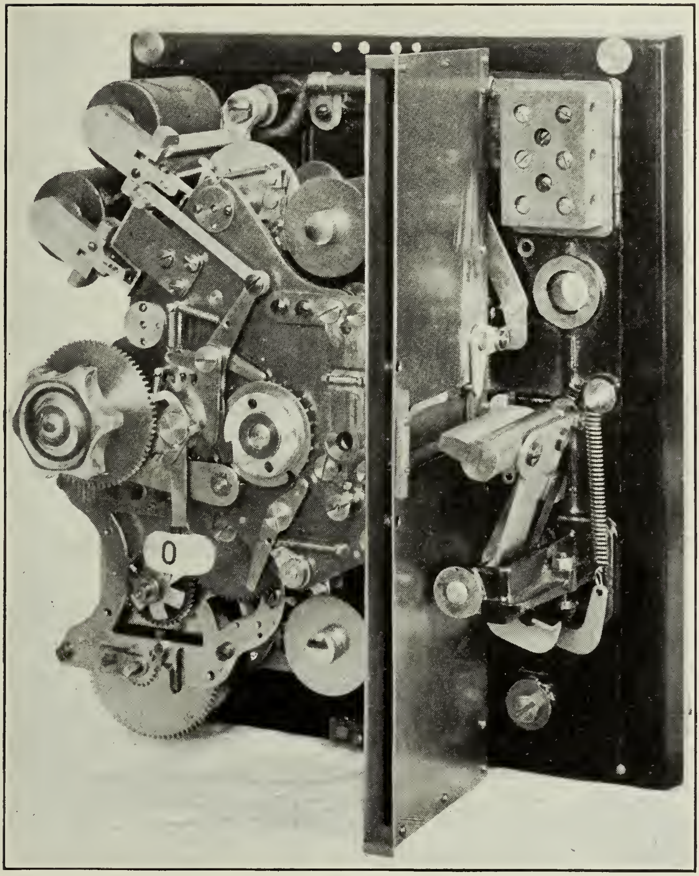


Fig. 3.

Similarly, the adaptability and advantages of high efficiency bearings, methods for lubrication, etc., can be checked, having the schedule running time, coasting time, etc., obtainable therewith in automatically printed record from the car or cars so equipped for comparison with similar records on the existing car equipment.

The consideration of the record (Fig. IV) from the Rico C. & S. Recorder will doubtless suggest to operating executives its availability for checking many other features encountered in practice.

The result of interest to the operating executive staff of a railway is the largest practicable reduction of power at the source of supply, where the cost of power originates. Such result can be obtained only by a constant and consistent checking of the motorman's efficient utilization of the controlling time-element factors.

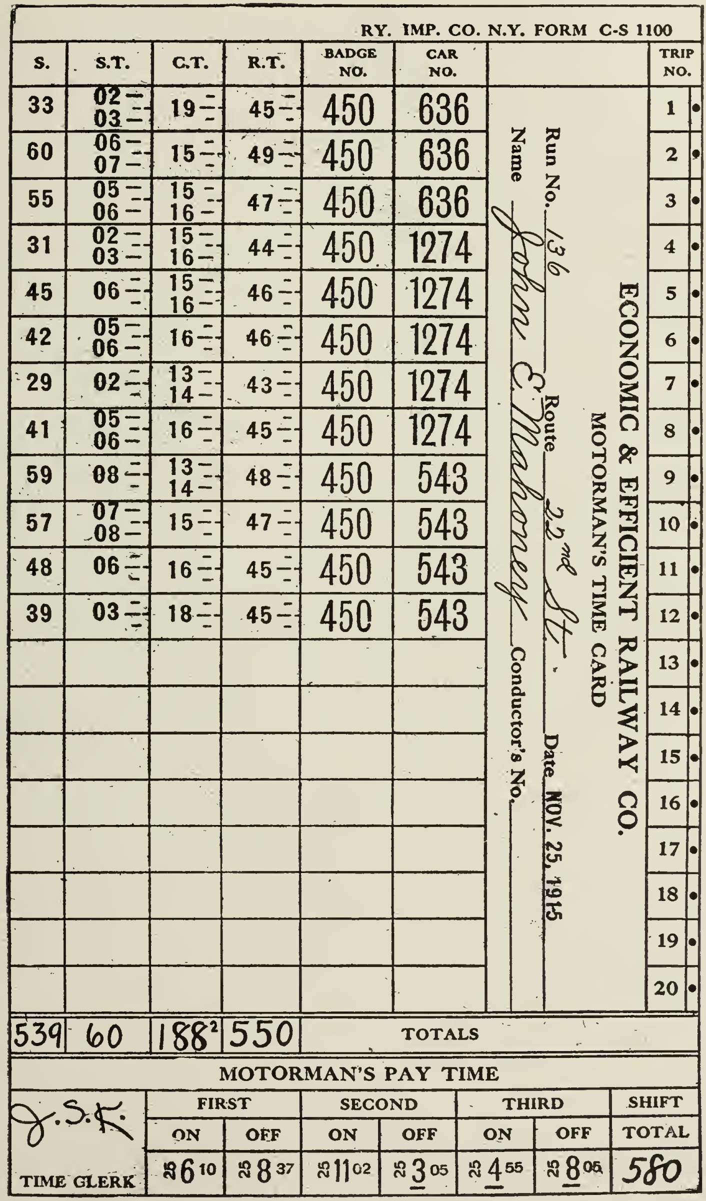
The efficient utilization of the controlling time-element factors is relatively correctly measured for any and all conditions of practical operation by the coasting time; any increase in coasting time (with schedule speed maintained) means more efficient utilization of the controlling time-element factors and consequently a reduction in power.

When equipped with the Rico Coasting Recorder or Rico C. & S. Recorder Efficiency Checking System, the motorman (maintaining schedule speed) has to deal only with the increase of his coasting time, which is automatically recorded in printed form for each trip. Thereby, he obtains the correct relative measure of existing efficiency—a guide and monitor for him and record data for the executive staff to compare with possible efficiency.

The operating results of more than 8,000 cars (on thirty-seven railways) whose operations are checked with the Rico Coasting Recorder efficiency checking system, are available. These results show 10% to 25% reduction in the power used for traction purposes, 15% to 45% reduction in brake shoe maintenance and a material though less tangible reduction in motor equipment maintenance and accident liability.

The results obtained by railway companies utilizing the Rico Coasting Recorder efficiency checking system, show net savings, after deducting maintenance and operating expenses for the Rico equipment, ranging from $50.00 to $200.00 per car per year, dependent upon the conditions of operation, the cost of power, etc. The analysis of results obtained in practice indicate that for the conditions of the average company, approximately the entire cost of the Rico Coasting Recorder equipment can be saved each year of its operation. The utilization of the Rico C. & S. Recorder now offered for commercial use should make possible even greater net savings.

Nearly two score of electric railways utilizing the Rico Coasting Recorder as an efficiency checking system, represent the widest possible range of topography, of speed, of congestion in traffic, car and train service, and of labor conditions.



RY. IMP. CO. N.Y. FORM C-S 1100

ECONOMIC & EFFICIENT RAILWAY CO.

MOTORMAN'S TIME CARD

Run No. 136 Route 22nd St. Date NOV. 25, 1915

Name John E Mahoney Conductor's No.

S.	S.T.	C.T.	R.T.	BADGE NO.	CAR NO.	TRIP NO.	
33	02 03	19	45	450	636	1	●
60	06 07	15	49	450	636	2	●
55	05 06	15 16	47	450	636	3	●
31	02 03	15 16	44	450	1274	4	●
45	06	15 16	46	450	1274	5	●
42	05 06	16	46	450	1274	6	●
29	02	13 14	43	450	1274	7	●
41	05 06	16	45	450	1274	8	●
59	08	13 14	48	450	543	9	●
57	07 08	15	47	450	543	10	●
48	06	16	45	450	543	11	●
39	03	18	45	450	543	12	●
						13	●
						14	●
						15	●
						16	●
						17	●
						18	●
						19	●
						20	●
539	60	188^{2}	550	TOTALS			

MOTORMAN'S PAY TIME

	FIRST		SECOND		THIRD		SHIFT
J.S.K.	ON	OFF	ON	OFF	ON	OFF	TOTAL
TIME CLERK	25 6 10	25 8 37	25 11 02	25 3 05	25 4 55	25 8 05	580

Fig. 4.

The success and practicability of the Coasting Recorder, therefore, is independent of local physical and operating conditions. It is easier to create than to maintain enthusiasm; the Coasting Recorder not only creates but maintains enthusiasm.

TABLE I

The Ratio of *increase* "Per cent. Coasting" to *decrease* "Per cent. Power" has been determined by carefully conducted tests, under actual conditions of operation, upon metered sections or systems of several typical railway companies, covering widely divergent operating conditions, as follows:

NAME OF ROAD	Ratio of Increase Per Cent. Coasting to Decrease Per Cent. Power
San Francisco-Oakland Term. Rwy.	1%—1.22% Saving
Denver Tramway Company	1%—1.1 % Saving
Pacific Electric Railway	1%—1.06% Saving
Met. West Side "L"—Chicago	1%—0.98% Saving
Bay State Street Railway	1%—1.05% Saving
Washington Railway & Elec. Co.	1%—1.02% Saving
Northern Texas Traction Co.	1%—1.2 % Saving
Los Angeles Railway Co.	1%—1.07% Saving
Empire United Railways	1%—0.78% Saving
Milwaukee Elec. Ry. & Lt. Co.	1%—1.07% Saving
San Antonio Trac. Co.	1%—0.99% Saving
Boston Elevated Railway Co.—Surface	1%—1.09% Saving
Elevated	1%—0.94% Saving
Syracuse Rapid Transit Co.	1%—1.19% Saving
Interborough Rapid Transit Co.	1%—0.91% Saving
Chicago Rys. Co.—(Surface)	1%—0.91% Saving

The above ratios obtained from actual tests appear slightly higher than the ratios indicated from several Speed Time and Power Diagram analyses. It should be borne in mind, however, such analyses assume constant voltage conditions, while in practice the decreased power resulting with coasting causes less voltage drop and hence corresponding improved voltage conditions, with consequent improved changes in the motor performance for such actual conditions of operation, thereby probably resulting in a higher ratio obtainable in actual operation.

PLANS OF THE AMERICAN ASSOCIATION OF ENGINEERS

By A. H. Krom, '10*

Synopsis: An article presenting the efforts of the American Association of Engineers to raise the standard of ethics of the engineering profession, and to promote the economic and social welfare of engineers.

In the early part of December, 1914, a few Chicago engineers met to discuss the Economic Problems of the Engineer, the principal topic being that the average engineer was underpaid and that a strong organization was necessary in order to gain proper recognition. Within a short time many representative engineers from all branches of the profession were interested and the study of this great movement was taken up through well directed energy by means of a temporary organization until our charter was received from the State of Illinois in May, 1915. Many valuable ideas were gained from the records of the "German Society of Technical Men Employed in the Industries," and our plans as well as the number on the membership list became greater until a great speed was gained for the movement during the three months previous to the First National Convention in December.

The subject of ways and means to bring about a greater appreciation of the engineering profession and the services of the engineer to the community and to the nation has been given increasing attention during recent years and has been discussed at meetings of the various engineering societies and in the technical press. Due to the size of this professional task, the other societies which are busy with their respective technical problems, have not undertaken this great work, therefore it remains for this body of all engineers to take up the "human" problems and to advance the material and social welfare of engineers as a profession.

It is a well known fact that, while wages and salaries in practically every other line of work, from day laborer to bank president, have increased greatly within the past few years, there has been no similar rise in the compensation of engineers. The salary of the average detail engineer is less than that of the average union tradesman, or skilled mechanic, while on the other hand he is forced to live on a higher social plane, so that his expenditures are almost equal to his income. Now let every technical graduate be fair with himself! What return above a fair living are you making on your engineering education, if you consider it as a business investment?

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*Engineer in charge of the Chicago Office, State Public Utilities Commission of Illinois.

It is to correct this condition of affairs and to render other equally important services to the profession that this Association was formed. The keynote of success is co-operation.

The American Association of Engineers will be devoted to the best interests of the average engineer of good standing. Not to elevate the already elevated but to bring up the standing of the rank and file to that attained in other professions. We solicit the support of the professor, the big engineers and employers of engineers and aim to command their respect through our services and objects and in the course of due time secure the same standing for the engineering profession as that enjoyed by the legal, medical and military professions—material compensation, consideration, and self-respect.

Our objects are: To raise the standard of ethics (stop knocking—begin boosting by co-operation) of the engineering profession and to promote the economic and social welfare of engineers:

1st. By affording means for the interchange of information—read the standard publication, "The Monad."

2nd. By maintaining a national service clearing house for engineering service, where each member will be classified as to education, training and experience by the Qualifications Committee and employers may refer their wants in the technical vocations to our Secretary who will send out confidential notices to all men who are qualified. Employers will be listed and members may make application for employment directly or through the Secretary. New work in all lines will be carefully listed in the Secretary's office and all important undertakings which require men skilled in the various arts will be printed in "The Monad" or its supplements, which each member will receive. New positions will be created by direct efforts of the Association's representatives.

3rd. By affording patent and legal advice—a new field for associated effort. Few technical men fully understand the constitutional rights of inventors; what a patent right really is or what rights an employer has in connection with development work performed by his employees. Valuable education in this direction may be gained from the Association and its publications.

4th. By supervision of legislation—an activity of the greatest importance, not only to the men engaged in professional work of a technical character but to the public in assisting legislators of the various state, municipal and national bodies to treat big subjects with scientific enlightenment and to place men who have technical ability in charge of all public enterprises where technical skill will apply to gain greater safety, economy and capacity for public welfare. Incidentally, the result will be to clear the field of its incompetents who infest political places and secure those places for the qualified engineer.

5th. By proper publicity. To educate the public is no easy task, but if every man will co-operate with the press bureau and at the same time be a walking disciple for the cause of being a living illustration of competent intelligence, worthy of better recognition, the result is bound to be elevation of the standards by which we are to be gauged—socially and financially.

The American Association of Engineers being primarily an association to gain better recognition for the technical profession must base its activities upon the personal qualification of its individual members.

Associate membership is given to all of those who are not directly engaged in technical pursuits, or those who may have a desire to assist in the elevation of the profession in other directions than the Certification and Employment Promotion (Service Clearing House) Departments.

Certified membership, according to our Constitution, may be extended to any citizen (or one who has taken oath of intention to become a citizen) of the United States of America, of good moral character, who is engaged in any branch of the sciences or technical arts, who shall be a graduate of any recognized technical school or college, who shall have had not less than two years' practical experience subsequent thereto, or who shall in lieu thereof, have had five (5) years' practical experience in engineering work. It is assumed that the applicant who has five years' practical experience as an engineer must have acquired sufficient technical knowledge to enable him to fill his position to the satisfaction of his employer.

The Monthly Bulletin will in addition to giving a review and listing the technical articles appearing in Trades and Scientific Journals, devote a large part of its space to an outline of interesting achievements of its members and their employers with a view to promoting their interests individually and collectively. This Bulletin will also present papers written by our members on subjects of professional ethics, patent law and comments on evils, uncomplimentary and unjust conditions which may exist in the industries, educational institutions and civic organizations where the technical profession is affected, from the position of draftsman to consulting engineer. No attempt will be made to regulate or stipulate salaries of members, but where practical, rates for consulting services and classified engineering work such as investigations, researches, analysis and estimates of costs requiring professional services to the general public will be classified and schedules of adopted minimums will be issued for the benefit of both the public and the profession at large.

To summarize the certification of engineers by the A. A. E., it is the fundamental channel through which we will elevate the standard of both compensation and ethics of the profession:

First: By establishing and demonstrating the recognizable worth of engineers in the various fields of industry.

Second: By eliminating the mediocre incumbent of positions requiring engineering skill and substituting therefor men of such ability as will redound to the elevation of the engineering profession through the element of efficiency.

Third: By assisting men with engineering qualifications into positions where their skill will become productive and recognized.

Fourth: By associating in a co-operative spirit and willing action, shedding upon the world a light representing usefulness to ourselves as well as to the industries to which engineering is but a servant in the interest of a better world.

In conclusion, the seven following features as printed by the Chicago daily papers might be noted:

1. Formed 6 months ago by 300 Chicago engineers drawn from the various engineering departments of the City of Chicago, State and Federal governments as well as those large industrial enterprises employing engineers in Chicago as for example the railroads, electric light, telephone companies, etc.

2. Formed for the purpose of bringing a closer relationship between the employer of engineers, the employee and the public. *Example*: Six or seven of the large rail

roads entering Chicago are spending millions on improvements, of which the public knows little and about which as citizens they ought to be better informed. This is due to the fact that the newspaper man can not be expected to understand technical problems and hence is not interested enough to cover the job. The American Association proposes to prepare such information periodically for the press as they will use in regard to big construction in the various parts of the United States. In Chicago in particular there are 25 to 30 big construction projects which the laymen public would be more interested in knowing than they would in the large space alloted to atrocities.

3. This is the first national engineering organization in the United States to have as members engineers drawn from all fields, such as civil, mechanical, electrical, chemical, etc.

4. This is the first national engineering organization in the United States to take up the welfare of the engineer and to try and put the engineer in touch with the job and the job with the engineer free. They have placed 100 men with jobs ranging up to $6,000.

5. This is the first national organization in the United States to attempt to make a stand against the policy of political machines appointing doctors, dentists, butchers, and barkeepers to engineering positions requiring the skill and exercise of mature and seasoned technical judgment.

6. This organization already has chapters in the process of formation in 19 cities. The seed is being sown, and the product, it is hoped, will mean a membership of 20,000 engineers by June, 1916. There are 100,000 engineers of all branches in the United States. The largest national organization for one branch alone is the American Society of Civil Engineers with about 7,500 members.

7. During the First National Convention held in Chicago, December 10 and 11, amendments were made so that engineering students may obtain Junior Memberships and receive practical business training while in school, and then after two years' experience in the profession, they can gain full memberships without the payment of an initiation fee.

EXPANSION AND CONSTRUCTION JOINTS IN REINFORCED CONCRETE VIADUCTS

By A. B. Cohen, '05*

Synopsis: Are expansion joints necessary and on what types of concrete construction?

What has been the experience of the D. L. & W. Ry. with expansion joints on the several large viaducts recently constructed on their system?

These questions and others pertaining to the details of expansion and construction joints, Mr. Cohen answers in this article.

Second only in importance to the determination of the most economical sections in reinforced concrete design of any magnitude, is the detail of expansion joints and following this consideration closely, is the location of the construction joints. These details are so important that it sometimes becomes necessary to waive economic considerations in order to properly provide for stresses due to temperature changes; to proportion sections for construction consistent with the daily capacity of the plant thus precluding the possibility of stopping work at a critical point that would impair the strength of an important member.

Expansion joints are unnecessary in bridges of about one hundred feet in length. The slight movement due to temperature changes is taken up by the elasticity of the structure. For greater lengths, the movement due to these changes becomes appreciable and owing to the low tensile strength of concrete, expansion joints dividing the structure into smaller units are necessary to prevent dangerous and unsightly cracks.

There is, however, a type of reinforced concrete construction known as the flat slab system which has been used for viaducts of great length without resorting to expansion joints. Eighteen and one-half acres of ground were covered by this type of design in the construction of the "Soo Line" Terminal at Chicago. The Delaware, Lackawanna & Western Railroad has just completed a combination viaduct and station of similar design, in eliminating the grade crossings by track elevation through South Orange, New Jersey. This system has also been adopted for an elevated structure supporting seven tracks in the Lackawanna Terminal improvements now under way at Buffalo, New York. The structure will be 150 feet in width and 1,000 feet in length.

The flat slab system consists of a slab of uniform cross-section, supported on columns forming panels 20 to 30 feet square. There are no beams or girders and the loads are carried from the slab directly to the columns. Because of the uniform cross-section, the slab can be effectively reinforced for changes in length due to temperature variations, by inserting steel bars to maintain a constant tensile strength throughout and particularly across the construction joints. Since steel and concrete have approximately equal rates of expansion, no amount of steel would prevent cracks resulting from the temperature changes. The steel, however, prevents cumulative action of the stress at any particular section and distributes the strain uniformly, resulting in an infinite number of minute cracks. Our experience with this type of construction does not extend over a sufficient length of time to ascertain definitely what effect the repeated action due to temperature changes will eventually have on the strength of the structure. Very close observations of existing structures of flat slab construction without expansion joints have disclosed no deleterious effect due to these causes.

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*Engineer of Concrete Design, Delaware, Lackawanna and Western Ry., Hoboken, N. J.

In concrete viaducts consisting of a series of arches, surmounted by transverse spandrel walls supporting a floor system, or in viaducts of the column, beam and slab design, the temperature changes are of more vital consequence. In the case of the beam and slab design, the constituent members have different sections and therefore offer varying degrees of tensile resistance. There arises the difficulty of transferring the movement due to temperature from the larger through the smaller members, as from the deep beams through the thin slabs. In the arch type, the very appreciable vertical movement of the heavy arch ring, for a rise and fall of temperature, is transferred to the comparatively light floor system, which must also resist its own movement in a horizontal plane. These movements cannot be resisted by the addition of any amount of steel, and expansion joints must therefore be provided.

In 1911, the Delaware, Lackawanna & Western Railroad completed two large concrete structures known as the Delaware River and Paulins Kill viaducts (see plate 1) on a 28-mile revision of the main line across the western part of New Jersey. In connection with the design of these structures, after an extended investigation had been made of existing structures of similar type, it was decided to construct the viaducts without expansion joints in the floor system. No precise data could be obtained at that time

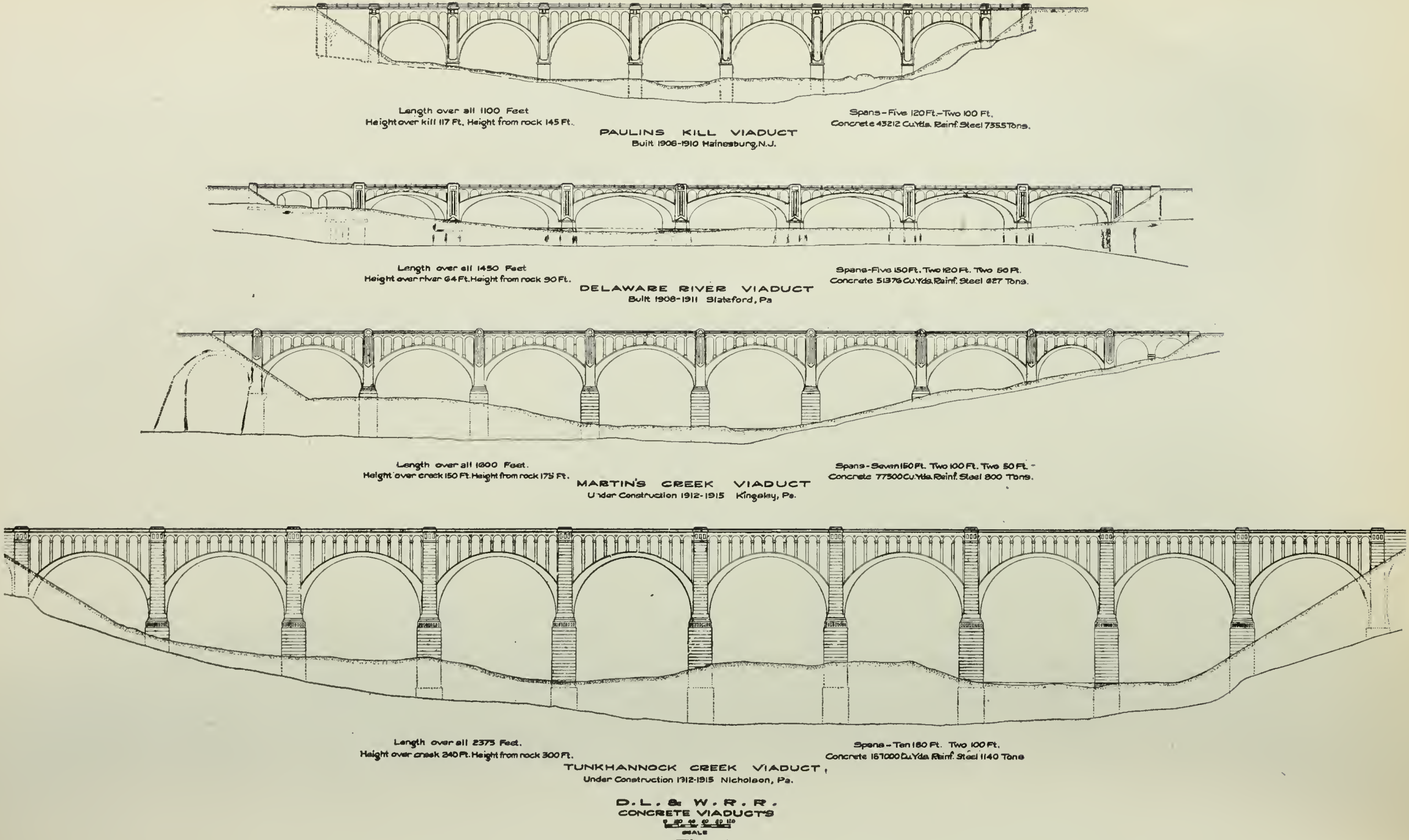
Length over all 1100 Feet
Height over kill 117 Ft. Height from rock 145 Ft.
PAULINS KILL VIADUCT
Built 1908-1910 Hainesburg, N.J.
Spans - Five 120 Ft. - Two 100 Ft.
Concrete 43212 Cu.Yds. Reinf. Steel 7355 Tons.
Length over all 1450 Feet
Height over river 64 Ft. Height from rock 90 Ft.
DELAWARE RIVER VIADUCT
Built 1908-1911 Slateford, Pa
Spans - Five 150 Ft. Two 120 Ft. Two 50 Ft.
Concrete 51376 Cu.Yds. Reinf. Steel 627 Tons.
Length over all 1600 Feet.
Height over creek 150 Ft. Height from rock 175 Ft.
MARTIN'S CREEK VIADUCT
Under Construction 1912-1915 Kingsley, Pa.
Spans - Seven 150 Ft. Two 100 Ft. Two 50 Ft.
Concrete 77500 Cu.Yds. Reinf. Steel 800 Tons.
Length over all 2375 Feet.
Height over creek 240 Ft. Height from rock 300 Ft.
TUNKHANNOCK CREEK VIADUCT,
Under Construction 1312-1915 Nicholson, Pa.
Spans - Ten 180 Ft. Two 100 Ft.
Concrete 167000 Cu.Yds. Reinf. Steel 1140 Tons
D. L. & W. R. R.
CONCRETE VIADUCTS
0 20 40 60 80 100
SCALE

Fig. 1.

concerning the extent of the seemingly small rise and fall of the existing arches. It was thought that most of the cracks, attributed to temperature changes, were due to shrinkage of the concrete in the first few months of construction and that if the viaducts with foundations carried to rock were built in such a manner as to minimize this action, the expansion joints could be eliminated.

The plan and sequence of construction were outlined in the following manner: the main arch rings were built in voussoir blocks about ten feet in length measured along the axis of the arch ring and spaced two feet apart. The blocks were allowed to set seven days before the two foot openings or keys were poured and twenty-eight days after the last key was poured the arch center was removed. This eliminated an undue settlement of the arch ring due to shrinkage and the theoretical crown elevation for which the arch was designed was further insured by cambering the arch center for its deflection under the ring load. No part of the floor system was built until the arch centers had been removed. The floor was built in alternate sections, but the reinforcing steel in the slab was continuous for the full length of the viaduct, which, in conjunction with the elasticity of the superstructure, was deemed adequate to resist the rise and fall of the arch ring without the formation of large cracks. It was expected that a number of small cracks would result from this movement, but these were not considered so objectionable as the leaky expansion joints that were in evidence on most of the structures inspected.

An examination of the Delaware River and Paulins Kill viaducts, after they had been in service for some time, disclosed the fact that large transverse cracks had formed at the crown of each of the two spandrel arches adjacent to every pier of the viaduct. This indicated that there had been a drop of the main arch rings due to fall in temperature. (See Plate II). Over the crown, the spandrel arches were in compression and no cracks developed while those adjacent to the pier were in tension. It may be here noted that the floor system was built during the summer months and therefore the movement in the main arch ring due to rise in temperature, would bring the floor system back to its normal position, or, if there were a movement beyond this it would be so slight as to make its effect on the floor system directly over the crown negligible, as compared with the effect of a fall in temperature on the floor adjacent to the piers.

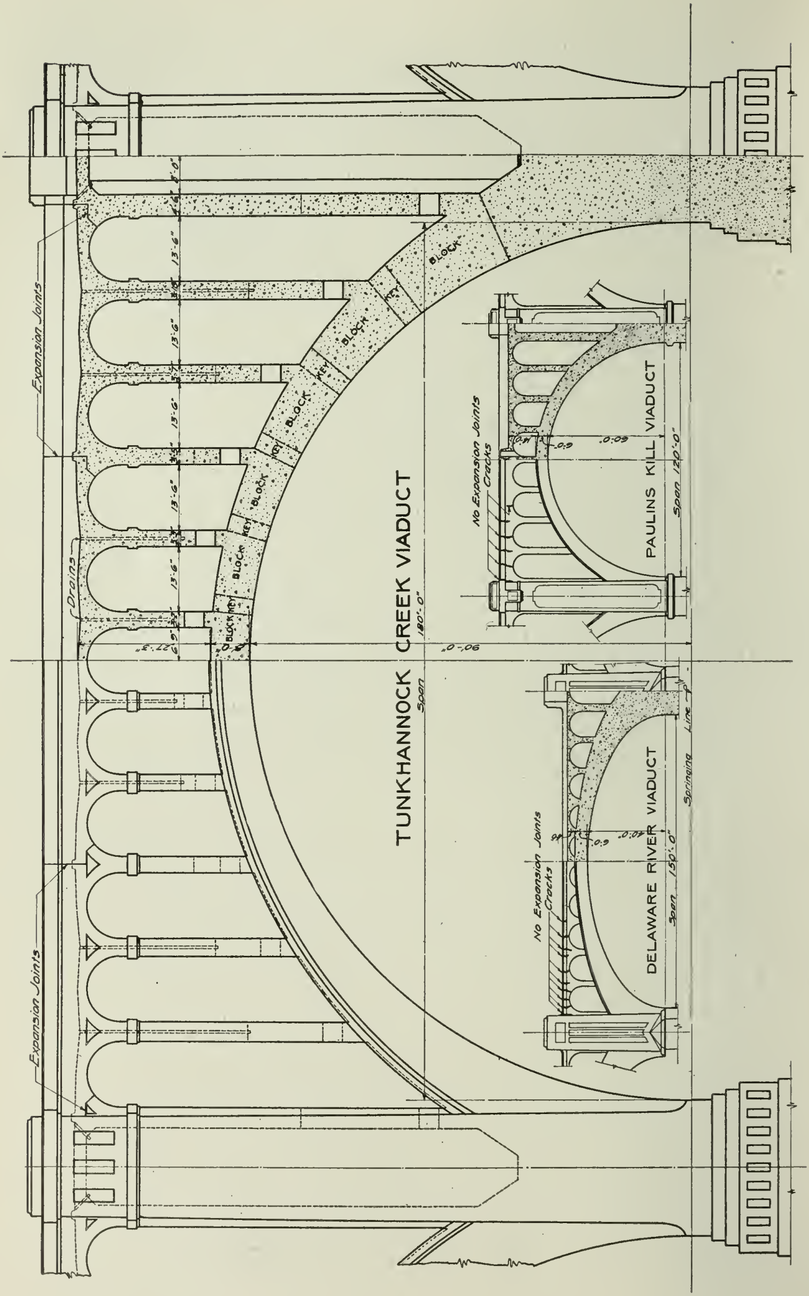
Expansion Joints
Drains
Expansion Joints
TUNKHANNOCK CREEK VIADUCT
Span 180'-0"
90'-0"
27'-3"
6'-0"
13'-6"
5'-0"
BLOCK
KEY
PAULINS KILL VIADUCT
Span 120'-0"
No Expansion Joints
Cracks
DELAWARE RIVER VIADUCT
Span 150'-0"
No Expansion Joints
Cracks
Springing Line

Fig. 2.

In view of the above observations, it was decided in designing the Tunkhannock and Martins Creek viaducts, recently completed on another revision of the main line west of Scranton, Pa., that expansion joints were necessary in the floor system at the piers and quarter points of every span. The quarter points of the span are approximately the points of contraflexure in the arch ring. For a fall in temperature the extrados of the arch ring between the points of contraflexure is in compression, beyond these points in tension and vice versa for a rise in temperature. The expansion joints divide the superstructure into three parts, separated at the points of contraflexure, each section acting in compression or tension as the case may be. This arrangement has proved successful for both viaducts, which have been exposed to the entire range of temperature.

In the detail of the expansion joints, it is imperative that a minimum amount of sliding surface be provided, otherwise the frictional resistance becomes greater than the tensile strength of the floor, which would cause cracks to develop adjacent to the so-called expansion joints. The sliding surfaces of the expansion joints of the big viaducts were lubricated by an asphaltic membrane. The drainage is prevented from percolating through the joints by dykes built across the floor.

As previously stated, the construction joints should be given careful consideration. It is a necessary precaution, in concrete design, to indicate the construction joints on the plans, in order to guide the foreman or superintendent who is frequently unfamiliar with the theory of design. Otherwise, a joint might be placed, for example, at a point of maximum shear, or at the junction of the stem and flange of a T beam. The massive solid piers of the Tunkhannock Creek viaduct were scored horizontally by nailing strips of moulding to the inside of the forms. These strips mark the construction joints four feet apart. Each of these sections contains 234 cubic yards, which is approximately the eight-hour capacity of a two-yard mixer. For the reinforced sections of the viaduct, the length of the reinforcing rods was so fixed that only the required lap projected beyond the construction joints, obviating the necessity of supporting dangling rods above the forms.

The precautions that were taken, to minimize the settlement due to shrinkage in the construction of the arch ring of the Delaware River and Paulins Kill viaducts, were repeated in the construction of the Tunkhannock and Martins Creek viaducts. Each main arch of these structures was built in two separate ribs. It is an interesting fact, that after the arch centers were struck, there was the slight settlement of one-quarter of an inch in one, one-eighth of an inch in three and no settlement in the other sixteen ribs.

Civil Engineering Building, Purdue University

FATALITIES AND SERIOUS SHOCKS CAUSED BY ELECTRICITY

By Geo. E. Glossop, '15*

Synopsis: This article treats in a non-technical manner of the subject of electric shock. It contains:

A classification of the injuries attributable to electricity, and their relative seriousness.

A comparison of the effect of alternating and direct current in producing a shock.

An explanation of the physiological effect of the electric current on the body, and the method of resuscitating a victim.

Time was when the mention of electric shocks suggested merely the sensations experienced in grasping the handles of the ordinary induction coil, or in receiving the discharge of a Leyden Jar. There are few persons who have not allowed an electric current to be passed through them by one or the other of the above means; and the sensation need scarcely be described. While the effect is usually of a mild and harmless nature, it is well known that shocks of an unpleasant character, even dangerous to human life, may be applied by such simple apparatus. Since electric wires are to be found overhead, underground, in nearly all buildings devoted to business, and in many of our homes, the subject of shocks is of interest to nearly everyone. With such widespread adoption of electricity for domestic and industrial use there have appeared occasionally in the public press notices of accidents due to electric shocks, sometimes attended with fatal results. These accounts, aside from the tragedy involved, are, as a rule, rather amusing to one knowing even the rudiments of electricity; all that can be learned from the daily papers is that it is safest to keep away from all wires. There appear to be proportionately few, outside those in the electric business, that seem to have any idea of what constitutes a dangerous shock, where one is likely to be obtained, and what "volts" and "amperes" have to do with it.

It is to be remembered that it is the amperes of current flowing, not in the wire but through the body, that causes the pain and the injury; the greater the number of amperes the greater the effect. Since voltage measured in volts, being somewhat analogous to pressure measured in pounds per square inch, forces a quantity of current or amperes, through the resistance offered by the human body or the wires, as pressure forces a quantity of water through the resistance of the water mains, it is readily understood that the greater the voltage the more current or amperes will flow through the given resistance. The size of the wire with which contacts are made is of little consequence; any ordinary wire can carry enough current to give a fatal shock; the number of volts does not depend at all upon the size of the wire.

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When electric current is flowing through the body a great deal of resistance is offered to the flow. The calloused palms of the working man offer the highest electrical resistance. The thick and hardened epidermis containing no blood or lymph is a poor conductor and, therefore, limits the amount of current that the man receives from the electrical circuit. However, it offers this high electrical resistance only to a momentary contact; while a continued contact will, in most instances, produce a secretion of perspiration which so moistens the skin as to give better conduction, thereby lowering the resistance. The resistance value apparently bears no relation to the height nor the cross-section of the individual but depends largely upon the resistance of the skin. When the skin has been burned through, the body resistance may readily reduce to 500 ohms. Therefore, the magnitude of the current which passes through the body is dependent upon the resistance of contact, the resistance of the body and to the conductivity of the surrounding atmosphere whether dry or damp.

The dangers peculiar to contact with electricity may be classified under four general heads. Those attributable to shocks; by shocks, meaning injuries due to the passage of current through the body. Those attributable to burns or injuries caused by burning some portion of the body that is in contact with the intense heat of an electric arc. Those attributable to flashes, or arcs, causing injury to the eyes by exposure to the intense light of the arc. Those attributable to falls caused primarily by shock or burn.

To receive a shock it is necessary that current flow into some portion of the body and out of some other portion. It is not the voltage that injures but the amount of current that is forced through the body; one one-hundredth of an ampere passing through the body will give the same sensation from a 500 volt circuit as it does from a 110 volt circuit. However, if the body resistance remains the same, nearly five times as much current will be forced through at a pressure of 500 volts as compared with 110 volts. Generally speaking, the higher the voltage involved, the greater will be the current through the body; the longer the duration of the contact, the greater the danger to life.

Burns usually accompany injury by shock, though it is possible to receive injury by a burn even where no shock is experienced. Such cases consist in the injured one coming into physical contact with an electric arc. A most annoying, though not deadly danger exists in the exposure of the delicate nerves of the eye to the intense brilliancy of an electric arc. The injury is not immediately apparent and often does not manifest itself for several hours. Eyes that have been exposed to electrical flashes become very red, due to the sudden dilation and congestion of the blood vessels of the mucous membrane that lines the lids and in part covers the eyeball. The surprise of a sudden shock, even though the shock itself is slight, may cause an unconscious contraction of the muscles, which may precipitate a man from a position otherwise secure. Such precipitation, however, assists in extricating him from what might be otherwise a dangerous contact.

There is a wide variety of external and individual conditions that influence the extent of electrical injury; individual susceptibility is a large factor, even the emotions play no inconsiderable role. For instance, there is on record that one lineman died purely of fright on touching a normally high tension line which, at the time of misfortune, carried no voltage whatever.

The experiments of Weiss, D'Arsonal, and others have enabled us to compare the respective behaviors of the alternating and direct currents. Weiss states that the alternating is about four times as deadly as the direct current. It might be thought that the danger would increase with the number of alternations, but this is not so, at least the variation of the periodicities used in the industries, varying from eleven to seventy-five cycles per second, makes no appreciable difference. D'Arsonal found that he could stand three amperes at 500000 to 1000000 alternations. This amount of current is twenty to thirty times as great as that required to kill a human being at the ordinary industrial frequency. High frequency currents, even at high pressures, are not ordinarily dangerous to life on account of their tendency to seek the surface of conductors rather than flow by way of an internal path.

Seventy to one hundred milliamperes of alternating current passing through the heart for a few seconds will cause death, whereas, with continuous current death does not occur unless about three hundred milliamperes are employed. Deaths have occurred from shocks at A. C. voltages as low as 65 and there are numerous instances of death at such pressures as 100 to 120 volts A. C. It is only under very exceptional circumstances, however, that these low voltages cause death; such as wet contact, which is equivalent to an extremely good contact, to a weak physique, and continued passage of current through a low body resistance. Although the continuous or direct current prevents more immediate danger, it may produce more lasting effects. It provokes, in the body traversed by it, actual electrical decomposition, the products of which are transported to the extremities, and this internal galvanoplasty may cause incurable injuries.

Physiological experimentation on animals adduces the conclusion that, as regards the death of human beings, it may be brought about by electric currents in several different ways. There is no doubt but that it might be due to prolonged tetanus of the muscles, which could prevent the performance of respiratory movements, and so lead to death by asphyxia. As a matter of fact, it has never apparently happened in this manner; the victim always being able either to break the contact and interrupt the passage of current for himself, or to call for help and have the contact broken by someone else before asphyxia has actually taken place. Primary heart failure is undoubtedly the most common mode of death. In this case, there is a cessation of respiration and cardiac action from electrical over-stimulation of the brain which thereby loses its power to react. This power to react is only temporarily suspended so that life, if not entirely extinct, is dependent on artificial respiration until such time as the brain recovers its power to react.

During the past thirty years a great many post-mortems have been made in cases of sudden death by electric shocks. Burns of greater or less superficial extent are generally seen at the point where the electric current has entered and left the body. In a word, the post-mortem evidence is generally negative, but may suggest asphyxia in some cases, in others organic vascular and nervous lesions in the brain and spinal cord.

It is contended by many physicians of note that if artificial respiration is immediately applied to the victim that there is much hope of recovery, particularly when the electric current has only temporarily paralyzed the nervous control of the muscles of respiration. This effect of shock is conceded to dominate in nearly all accidents where the contact was of short duration. Hope of resuscitation is, however, restricted to the proper treatment of cases of paralyzed respiration and, since deprivation of oxygen injures immediately some of the nerve centers of the brain, it is particularly important that measures for resuscitation be applied immediately and continued until natural breathing returns.

The prone pressure method of artificial respiration, which has been given universal publicity and is today taught to all employees of large corporations, consists in laying the injured on his belly with his arms stretched forward. Pressure is applied rhythmically on the loins and lowest ribs. The advantages of this method are: that the operation is simple and easy to perform, that there is no need of a second person to hold the tongue from falling back and blocking the air passages, that there is little danger of injuring the liver or breaking the ribs if pressure is gradually and not violently applied, and that a larger ventilation of the lungs is accomplished.

In general, the resistance of the human body is normally so high that, with pressures not exceeding 500 volts, accidental contacts are rarely fatal. The greater number of fatalities attend the severe burns caused by momentary contact with high voltages and falls due to the unexpected shock.

Electrical Engineering Building, Purdue University.

NOTES ON ESTIMATING THE GROWTH OF CITIES

By H. G. RASCHBACHER, '04*

Synopsis: Showing how to obtain the approximate future population of a city from its past growth and its present size.

During the years 1914-1915, the writer was engaged in assisting a former classmate in preparing a report for a certain eastern city, covering the collection and disposal of all classes of municipal wastes. One of the chief questions to be determined before submitting the report was the size of the recommended plants, which in turn depended upon the quantities of the various wastes produced by the population served in 1940. The production per capita of any class of waste was easily determined by a series of complete field studies, but when the question of estimating the future population arose, few data were to be found that would furnish a reliable program for determining such an estimate. It was finally decided to plot the available census data and estimate the future population from a straight line curve. Before doing so, the writer endeavored to ascertain if there were any determinable law or laws governing the growth of cities except a mere estimate of what future conditions were liable to be. While the studies made did not attain the end for which they were carried out, a number of interesting facts were brought to light and it is felt that they are of sufficient interest to be of some value to readers of the Purdue Engineering Review.

In general the population curve for any city can be plotted by the formula, $P = M\,Y^n + C$, where, P is the population for any particular year, M, a numerical coefficient, Y, the number of years elapsing from the first plotted on the curve to the one for which the population is desired, ^{n}, an exponent determined from the available data at hand and C, the population of the city in the first year plotted on the curve. By substituting the data at hand for all the American cities as furnished by the Bureau of the Census in the above equation, a series of equations results for any particular city, in which P, M and ^{n} are the only unknowns. By the method of Least Squares, these can be brought to two simultaneous equations in which M and ^{n} can be determined and a resultant equation found in which P is the only unknown. By substituting in this equation for any future year the population determined will be a value lying in the curve which is the closest to passing through all the points which may be plotted from any data which may be available.

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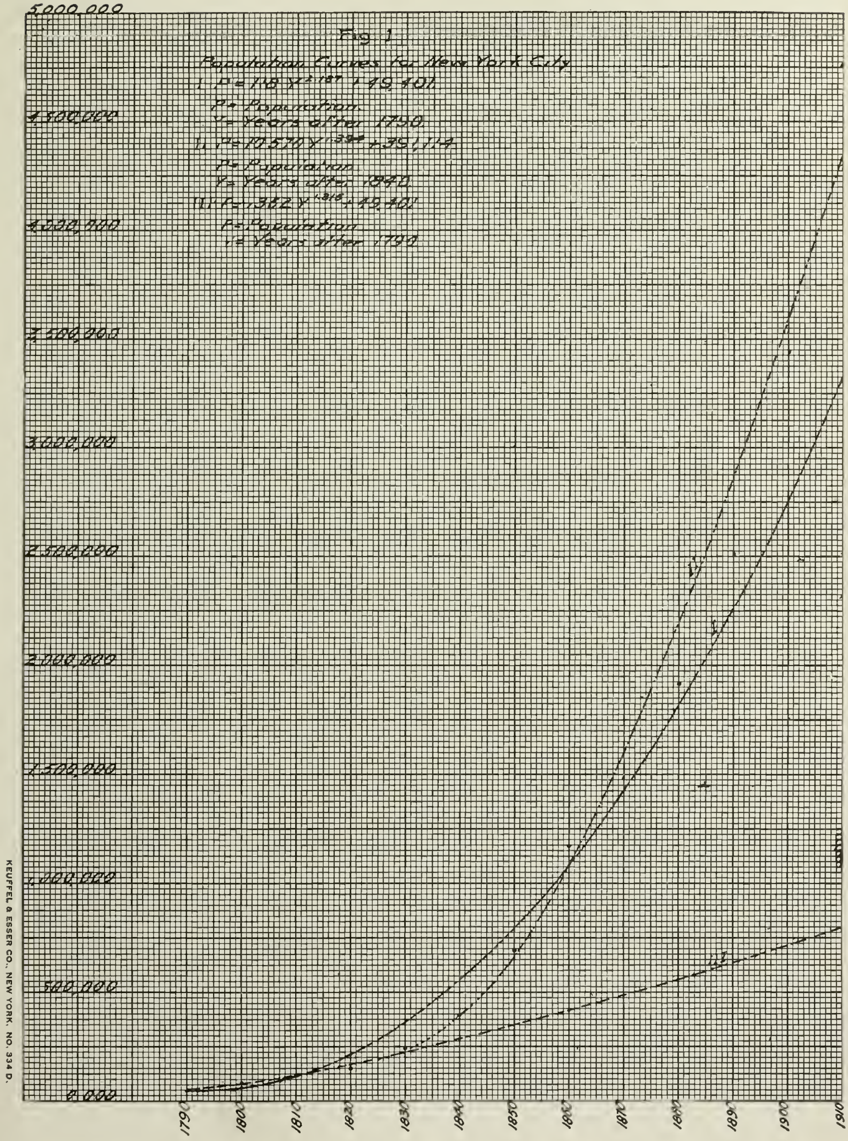
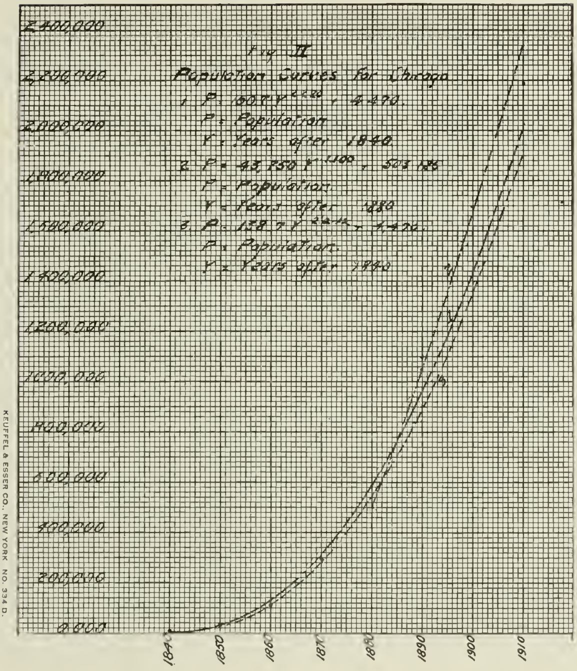


Fig. 1
Population Curves for New York City
I P=118 Y^2.187 + 49,401
P= Population
Y= Years after 1790
II P=10,570 Y^1.394 + 351,114
P= Population
Y= Years after 1840
III P=.382 Y^1.815 + 49,401
P= Population
Y= Years after 1790
5,000,000
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0,000
1790
1800
1810
1820
1830
1840
1850
1860
1870
1880
1890
1900
1910
I
II
III
KEUFFEL & ESSER CO., NEW YORK. NO. 334 D.

In carrying on the studies made, population curves were worked up for the following cities: Baltimore, Boston, Chicago, Cleveland, New York, Philadelphia, Pittsburg, and St. Louis. These cities comprise the eight largest cities in the country according to the last U. S. census, they present a fairly wide geographical range, the conditions which affected their growth could hardly have been very similar and census information was available for the majority of the cities for a period of 120 years. For these reasons, it was felt that if any general law could be deduced from the information covering these cities, it would be applicable to a fairly wide range of conditions, not only as regards geographical location, but size of the city as well.

Three curves were worked out for each city listed above, and numbered 1, 2, and 3. Curve No. 1, was that curve which would most nearly pass through the points plotted for the entire period for which census data was available. Curve No. 2 was plotted from the data for all years following that in which the population reached 500,000 in the case of New York, Chicago and Philadelphia, and 250,000 for the remaining five cities. Curve No. 3 was plotted from the data for all years until the population reached 500,000 for New York, Chicago and Philadelphia, and 250,000 for the remaining five cities. Curve No. 1 will represent the population curve which will take into account all the conditions affecting the growth of a big city from its beginning as a city of any size, up to the present time. Curve No. 2 will represent the population curve which takes into account only those conditions affecting the growth of a city after it has become a city of importance. Curve No. 3 will represent the population curve which takes into account only those conditions affecting the growth of a city from its beginning until it becomes a city of importance. The use of Curve No. 3 would enable one to estimate the population of a city which at the present time had less than 500,000 or 250,000 inhabitants. Curve No. 2 would enable one to estimate the future population of a city which at the present time had over 250,000 or 500,000 inhabitants. If the values taken from the extension of Curve No. 3 were approximately the same as those from Curve No. 2, and if the values from either 2 or 3 were approximately the same as those from Curve No. 1, proof would have been established that the law governing the growth of cities of any size was a uniform law throughout their growth and in that case a general formula could be deduced which would represent the growth of any city throughout its life.



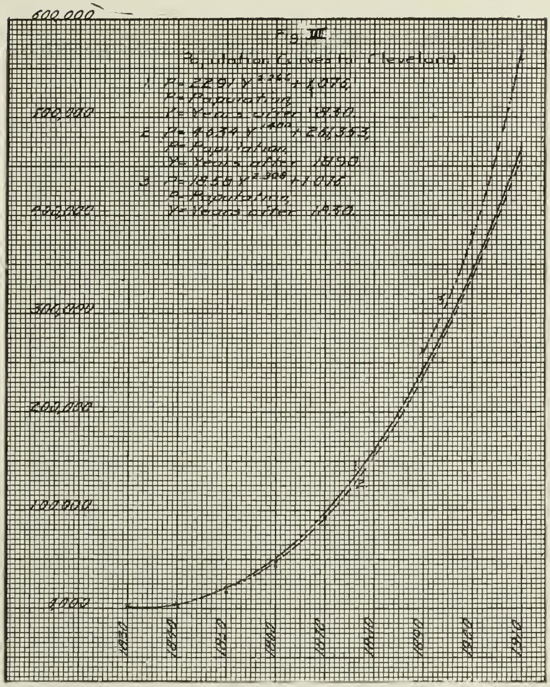
The curves covering the above conditions may be plotted from the following formulae:

New York . . . Curve No. 1, $P = 118\ Y^{2.137} + 49{,}401$
where Y = years after 1790.
Curve No. 2, $P = 101570\ Y^{1.394} + 391{,}114$
where Y = years after 1840.
Curve No. 3, $P = 1362\ Y^{1.316} + 49{,}401$
where Y = years after 1790.
Chicago. . . . . . Curve No. 1, $P = 160.7\ Y^{2.220} + 4{,}470$
where Y = years after 1840.
Curve No. 2, $P = 43.750\ Y^{1.100} + 503{,}185$
where Y = years after 1880.
Curve No. 3, $P = 138.7\ Y^{2.242} + 4{,}470$
where Y = years after 1840.
Philadelphia. . Curve No. 1, $P = 152.4\ Y^{1.794} + 28{,}522$
where Y = years after 1790
Curve No. 2, $P = 3{,}133\ Y^{1.489} + 565{,}529$
where Y = years after 1860.
Curve No. 3, $P = 691.8\ Y^{1.187} + 28{,}522$
where Y = years after 1790

Baltimore.... Curve No. 1, $P = 242.7\ Y^{1.592} + 13{,}503$
where Y = years after 1790.
Curve No. 2, $P = 3327\ Y^{1.263} + 267{,}354$
where Y = years after 1870.
Curve No. 3, $P = 523.6\ Y^{1.360} + 13{,}503$
where Y = years after 1790.
Cleveland .... Curve No. 1, $P = 22.91\ Y^{2.266} + 1{,}076$
where Y = years after 1830.
Curve No. 2, $P = 4{,}634\ Y^{1.400} + 261{,}353$
where Y = years after 1890.
Curve No. 3, $P = 18.58\ Y^{2.308} + 1{,}076$
where Y = years after 1830.
Pittsburg..... Curve No. 1, $P = 9.55\ Y^{2.269} + 1{,}565$
where Y = years after 1800.
Curve No. 2, $P = 15{,}140\ Y^{0.875} + 235{,}071$
where Y = years after 1880.
Curve No. 3, $P = 12.02\ Y^{2.178} + 1{,}565$
where Y = years after 1800.
St. Louis..... Curve No. 1, $P = 4{,}487\ Y^{1.176} + 16{,}469$
where Y = years after 1840.
Curve No. 2, $P = 1{,}362\ Y^{1.526} + 310{,}864$
where Y = years after 1870.
Curve No. 3, $P = 2{,}576\ Y^{1.359} + 16{,}469$
where Y = years after 1840.
Boston....... Curve No. 1, $P = 28.05\ Y^{2.053} + 18{,}320$
where Y = years after 1790.
Curve No. 2, $P = 3{,}639\ Y^{1.333} + 362{,}839$
where Y = years after 1880.
Curve No. 3, $P = 99.31\ Y^{1.712} + 18{,}320$
where Y = years after 1790.

It is obvious that the factors governing the growth of the cities studied are different in each case and no common curve or formula can be deduced which will apply with reasonable accuracy to all. The most peculiar fact which may be noted, however, is that after the population of a city reaches 250,000 or 300,000, the rate of increase becomes much greater and the curve shows a pronounced inclination towards the vertical. This characteristic seems to prevail regardless of the present size of the city, its location, or the time in which it reached the population noted. The following table illustrates the above statements more clearly, the date given being the census year in which the population reached or passed 250,000 or 300,000:

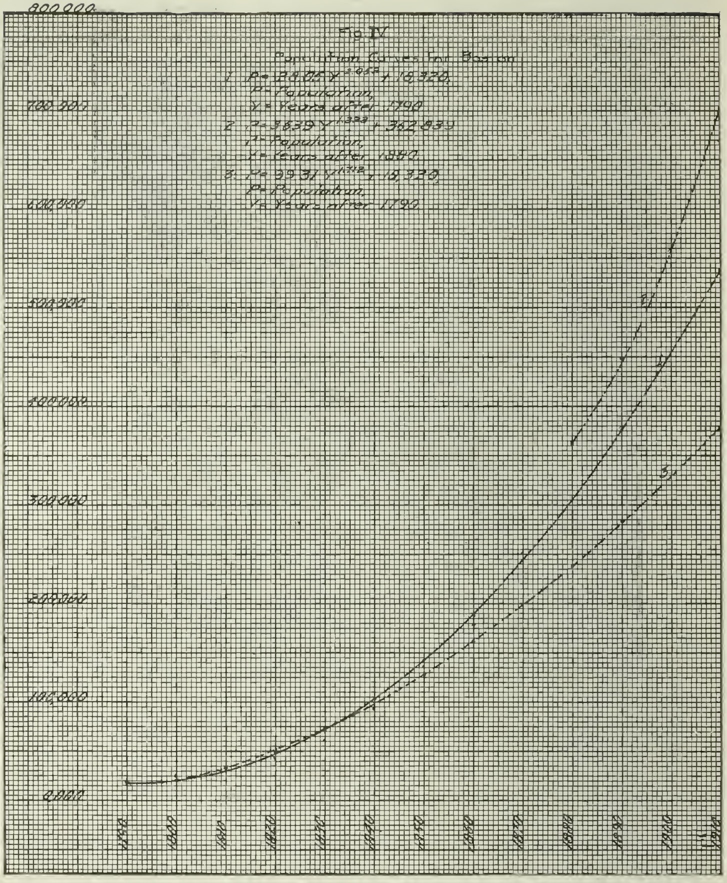
New York	1840
Chicago	1870
Philadelphia	1860



Baltimore	1880
Cleveland	1890
Pittsburg	1880
St. Louis	1870
Boston	1880

Another characteristic which may be noted is that eastern cities show a much slower rate of increase than is the case with the western cities. The curves for Chicago, Cleveland and St. Louis show this uniformity as a group, and the same holds true for the curves for New York, Philadelphia, Boston, Baltimore, Pittsburg.

Among the western cities studied, little effect is shown in the rate of increase due to facilities for transportation by water. The rate of increase for the lake cities, Chicago and Cleveland, does not differ materially from the rate of increase for St. Louis, water transportation on the Mississippi not being considered as comparable with lake shipping. The same characteristic seems to hold true in the eastern cities studied. The rate of increase for Pittsburg being about the



same as for Boston, Baltimore, and for New York and Philadelphia when the two latter cities were of about the same size as Pittsburg is now.

From the data at hand it seems logical to assume that; when a city reaches a population of about 500,000, the natural resources, tributary, rail and water transportation facilities and opportunities for expansion by annexation, etc., are present in such degree that they have carried the city over what may be termed the critical period prevailing when the population is less than 300,000 and that from this time on the rate of increase will be uniform and more rapid than was the case before the population reached 500,000;

that cities which lie in what may be termed the central or western sections of the country will show a much more pronounced rate of increase at all times than is the case with cities in the eastern or southern sections of the country; that the rate of increase of all cities, regardless of location, transportation facilities and tributary country surrounding, is much less when the population is less than 300,000 than is the case after the population has passed that figure.

During the course of the investigations mentioned at the beginning of this article, the writer made a study of the methods in use at the present time among engineers in estimating future growth of cities and found no reasonable uniformity among them. In a more or less vague way, the prospects for future expansion are dependent entirely upon the judgment of the estimator as to what conditions will prevail after a period of 25 or 50 years has passed. Inasmuch as no man can know what the future holds in store, it seems to the writer that the safest plan is to let the past govern the prospects for the future, provided there are sufficient data covering the past, and prolong the curve to estimate the conditions in the future. This seems to be especially true if the data be separated into two parts and those dealing with the population below 250,000, used for estimates up to 500,000; while the data dealing with population above 250,000 are to be used for all future estimates.

So far as the writer is aware, the Bureau of the Census is the only estimator which governs its estimates of future population entirely upon records of the past. That Bureau uses the straight line formula entirely, stating that their experience shows this to give the more accurate results. While they recommend this formula, they do not officially endorse it. Curves worked out according to the theory of least squares, check fairly closely with the straight line curve mentioned above, though the values from the straight line curve are generally slightly below those submitted by the writer.

THE EVOLUTION OF EXCAVATING MACHINERY

By J. D. Rauch, ex-'95*

Synopsis: A short history of dredges and steam shovels, and the conditions which have caused their rapid development.

Probably one of the most obscure classes of machinery, yet one that has contributed much to the development of the country as well as the conservation of our natural resources, is that employed in the excavation of drainage and irrigation ditches as well as canals and other engineering operations for the development of commerce and industry.

Such machinery may be divided into two general classes: First, that which is mounted on floats or barges for excavation in water; and second, that which is mounted on trucks or platforms for dry excavation.

At the time when our middle west was being settled, and before the advent of the railroads, canals were the only means offered for cheap transportation and many great canal systems were built at considerable cost. The vast amount of excavation required in the construction of these canals was done chiefly by hand labor—and yet this was so short a time ago as to still be clearly within the recollection of persons living today.

Within a few years, however, railroads began to be constructed, with which the canals could not compete as common carriers. It has often been a matter of conjecture to the writer as to what the result might have been had they possessed the efficient excavating machinery then that we have today.

But these canals did more while in operation than to provide avenues of commerce. They served as drains for the adjacent lands, greatly increasing their fertility and value and naturally creating in the minds of men the desire to further expand this phase of reclamation.

As the country became more thickly settled the great areas of wet and overflowed lands in the middle states and especially in Illinois and Indiana attracted attention and means were considered for carrying off the water by artificial channels.

These channels, or ditches we may call them, were first excavated by manual labor. The results obtained in reclaiming the land were sufficient to justify the necessity of some more extensive and efficient means of excavation and efforts were made to construct machinery to do the work.

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* Sec'y-Treas., The American Steel Dredge Co., Fort Wayne, Ind.

About the year 1880 a crude but fairly successful ditching dredge was built in northeastern Illinois. This machine was not only capable of doing the work better, but so much cheaper than any former methods that it immediately commanded attention. It was the nucleus of what is now generally known as the dipper dredge—a type which, with the many improvements made since its advent, is recognized as the most efficient and economical type and is employed almost exclusively today in drainage work, as well as in the canal construction and deepening of our rivers and harbors. The dipper dredge is essentially an American machine. It has shown its superiority over other types in many instances, the most important example being probably the construction of the Panama Canal, which was successfully accomplished after several futile attempts with foreign types.

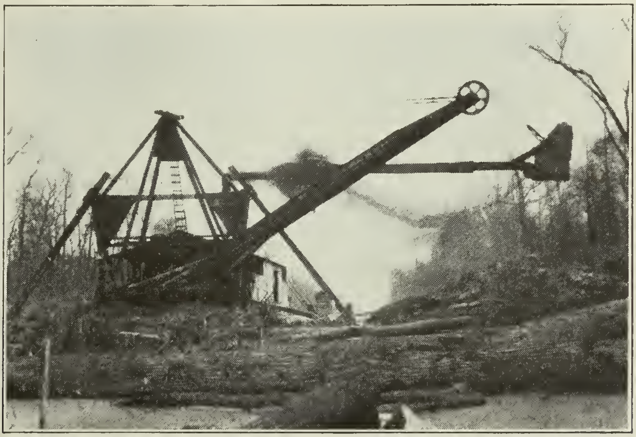

Fig. 1. Dipper Dredge.

Originally dredges were constructed with wooden booms and superstructure and mounted on wooden barges. The modern dredge is built of steel throughout including the barge, as shown in the accompanying illustration, and is capable of coping with the most heavy and difficult work.

With the vast areas of waste lands yet to be reclaimed, and the untold canals and harbors for commerce yet to be conceived in this and other countries, this class of machinery offers a most promising field for the mechanical and perhaps the electrical engineer; and for the civil engineer in the planning and maintenance of the work.

We now come to the other, but no less important, branch known as dry excavation, which embraces even a wider and more varied field, such as canals for carrying and distributing water in the irrigation of arid regions, the construction of modern roads, which is just now opening up in almost inconceivable proportions in every section, and on down to subway and tunnel excavation, as well as a myriad of other but equally important and economic operations.

For such work the steam shovel was evolved and has been brought to a state of efficiency that is astounding.

One of the latest and most universal types is what is known as the revolving shovel, such as is shown in the accompanying illustration (Fig. 2.) It is mounted on a swiveling truck so as to revolve in a complete circle, and is capable of traveling from point to point under its own power.

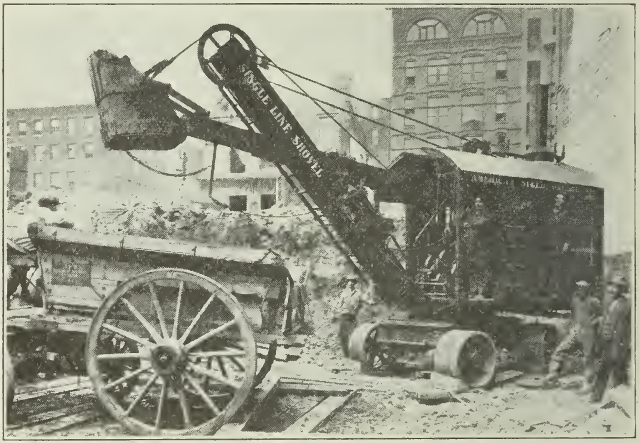

Fig. 2. Revolving Shovel.

For years practically all the iron ore from the ranges of the Northwest has not only been mined and loaded into cars by steam shovels, but the beds of ore have been previously stripped of the overburden of soil by the same machines. This has been a most important factor in the development of the steel industry, and its effect on the cost as well as the increased production of iron and steel can hardly be computed.

The field is still open for unlimited improvements and each year brings forth new opportunities for expanding the range of usefulness of machinery of this class, which should not be overlooked by the engineer.

PRINCIPLES OF DRAINAGE DISTRICT ASSESSMENTS

By R. G. FLAUGHER, '12*

Synopsis: The engineer in charge of drainage projects meets many problems in his contact with owners of farming land and by no means the last of these is the question of apportioning assessments according to the value which an individual will receive, and to the location of his ground. In this article Mr. Flaugher summarizes methods of assessments which have been used successfully.

Perhaps in few fields of his endeavor is the engineer required to exercise more tact and perseverance than in that of drainage engineering. The great variety of conditions in the topography of the drainage area, the varying degrees of soil fertility, the relative distances of certain tracts from the main ditch and the completeness or incompleteness of the drainage, combine to make the task of handling a drainage district far from a simple one. Furthermore, because of friction between the interested parties concerning matters connected with the drainage work, the engineer is often caused much embarrassment.

The only course to follow is that of strict adherence to engineering principles and close observance of the state drainage laws, as well as the use of common sense, tact, and neutrality.

It is impossible to lay down a set method to follow in the levying of assessments or the awarding of damages. There are, however, ten fundamental principles which apply in the making up of an assessment roll for a district.

1. A land-owner is by virtue of ownership entitled to any drainage that his land may possess. He may construct any system of drains that he deems necessary so long as it is done within the limits of his land, provided the outlet is in a natural watercourse through his own holdings.

2. If the natural outlet for the territory surrounding him is through his own property he cannot be assessed for any part of a public drainage system unless it is evident that he is actually benefited by the drainage of the adjoining property. Where the natural slope of the surrounding land is such that without a drainage system he would be compelled to take care of the water coming from above his land, then the public drainage system will benefit him to the extent of the injury suffered because of the wet condition of the surrounding land.

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* Cayuga, Ind.

3. If no such condition exists and no other benefit is apparent the assessment should be omitted. On the other hand, he is entitled to recompense for the right of way necessary for the public drainage ditch through his land. Where the owner refuses permission for the construction of the drainage ditch through his holdings, the authorities may condemn such land for public purposes. The right of passage cannot be withheld. The owner is awarded such damages as is necessary to cover injuries sustained, by a jury appointed for such purposes.

4. Other things being equal, the greater the amount of water removed from a tract of land, the greater the amount of assessment levied. An area that is wet and useless for agricultural purposes should be assessed proportionately higher if reclaimed by the construction of an adequate drainage system than other land lying in the same district which has better natural drainage.

5. The land occupied by the right of way should not be assessed for benefits, since it is evident that owner will never receive any direct returns in the future. The number of acres used for this purpose on each piece of land should be subtracted from the total area and not be considered on the assessment sheet. Although, theoretically this is correct, the amount involved except in expensive improvements and large areas owned by the same individual is negligible. This point is nearly always disregarded.

6. Where, within the limits of a district, the soils because of their type or structure are variable in fertility, those most fertile should be assessed proportionately higher than those possessing a lesser degree of fertility.

Sometimes it occurs that one tract is capable of producing higher priced crops, while others are only available for the production of ordinary crops. This condition has often obtained in the Kankakee regions of northwestern Indiana and northeastern Illinois, where the proximity to the Chicago markets renders the various types of loam and sandy loam soils very valuable for the production of market garden crops.

7. If a public drain incidentally passes through a tract of land for the purpose of giving more perfect drainage privileges to the surrounding area, and in so doing affords direct drainage to the particular tract as well as decreases the expenditure necessary to complete its drainage, this land should be assessed proportionately higher than the land adjoining for the reason that private drainage has been accomplished

at public expense. It is, however, necessary for the proper authorities of the drainage district to prove their point in a case of this kind. Just such technical questions as these are constantly arising. They afford no end of worry to the engineer and no end of remuneration for the members of the legal profession.

8. The nearer a tract of land lies to the natural outlet the smaller the assessment should be, provided the drainage advantages are the same. The basis of this principle lies in the fact that the land more distant from the outlet has been brought within the reach of drainage facilities. The land contiguous to the drainage ditch possessed such facilities previous to the construction of the main outlet.

9. If complete drainage is not furnished to the lands of an entire tract, those which receive only partial drainage should be assessed in proportion to the benefits received.

10. Outlet privileges should be assessed in proportion to the distances from the drainage ditch.

In the construction of any public artificial drainage system, it is seldom possible to avoid damages to property in some manner or other. Although the chief cause for damages is the use of land necessary for right of way, there are other claims for which damages are allowed.

The cutting up of fields into irregular and small tracts causes extra time and labor for the cultivation and harvesting of crops; the proximity of the ditch to certain structures and the destruction of the water loving timber, are sources for the awarding of damages. Again the destruction of growing crops and the cost of construction of additional fences demand remuneration.

Next to the damage to land for right of way purposes, the damages to highway and railroad properties are most important. Traffic on highways is often stopped or averted during the construction of the ditch itself or of the bridges incident thereto. The excavated material must be removed, causing some expense.

Railroads are affected to a greater degree than highways. Traffic is entirely dependent upon a continuous line of steel and a firm and undisturbed roadbed. It is usually extremely costly or impractical to provide a sidetrack for temporary purposes. Detouring is not always possible. Of course damages are sometimes allowed, but seldom commensurate to the expenses of delay and inconvenience involved. Often a new bridge must provide for the outlet, or an old structure be replaced by a new one because of additional water carried. The railroad pays for the new bridge, of course. The railroad also pays an additional assessment for other benefits received, which, in justice, let it be said, are often many. The value of a well drained roadbed is very great. Furthermore, the welfare of any railroad is directly dependent upon the agricultural resources of territory through which it passes.

The management of a drainage district involves no little responsibility, and the drainage engineer must possess special training. He must not let enthusiasm for his work carry him beyond the bounds of engineering technique. He must be a wise and honest counsellor, he must be well versed in the knowledge of civil engineering, agriculture, drainage law and human nature.

SOME PERSONAL IMPRESSIONS OF AVIATION.

By J. C. Turpin, '08*

Synopsis: Mr. Turpin, who was one of the first pupils of the Wright Brothers in the study of aviation, and whom we all remember as being one of the famous members of the original Wright exhibition team, tells in a most interesting way of some of his experiences while engaged in this very strenuous sport. It might be well to add that Mr. Turpin and Mr. Walter Brookins are the only members of the original team that are alive today, both of them having retired from the game several years ago.

So much has already been written in regard to aviation that the following article will deal entirely with my personal affiliations in the flying game. My entering into this, one of the most alluring of sports, was during the early Spring of 1910, when I was approached by Mr. Orville Wright who gave me the opportunity of becoming one of seven of the initial members of the Wright exhibition team. My early training began in Dayton, Ohio, under the personal tutelage of Mr. Orville Wright.

To the uninitiated, learning to fly an aeroplane must seem like a very easy task, but I can assure those who have this opinion that this is not at all true. All training of men, then as well as now, is done in a machine in the air, under the direction of a proficient instructor. The required time for a man learning to fly an aeroplane usually covers a period of about four weeks, as the training of new pilots can only be conducted under the most favorable weather conditions, by which I mean that air conditions must be absolutely calm. These conditions are most prevalent in the early morning and the late afternoon.

In driving an aeroplane four directions must be considered, the two directions fore and aft, and also the side balance of the machine. The side-balance is controlled by what is called warping the planes. If the right side of the machine is low, the wings on that side of the machine are warped or lowered. These lowered planes meeting the onrush of air, offer more resistance to it, and are immediately raised. In like manner, if the left side of the machine is low, the left wings are warped, more surface is exposed to the air and this side of the machine is therefore raised. The elevation and inclination of the plane is controlled by a rear elevating rudder. In the first types of planes built by the Wrights the motor was controlled by a foot lever, being fully accelerated at the time of starting, and running under full power during the entire time of flight, only being throttled down for making landings.

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* The American Cotton Co., Boston, Mass.

The landing on an aeroplane is by far the most difficult operation in flying, for it is only at this time in coming close to the ground that the operator realizes the extreme speed of the machine. When one considers that a machine of extremely light construction and weighing around 1200 lbs. with the operator, is compelled to land at the rate of from fifty to sixty miles per hour on sometimes very rough ground, one can easily understand the skill it requires to avoid demolishing the planes.

My first lesson and also my first ride in an aeroplane was to me an extremely disagreeable experience. The nearest approach to a comparison is that of riding in an automobile at the rate of fifty or sixty miles and hour over very rough roads. The statements of those of my passengers whom I took up in later days that they had enjoyed the experience immensely, I always took "with a grain of salt," as I knew very well that while they were glad to have had the experience, they were more glad to again be able to place their feet on solid ground. I never experiencd in all my flying career the sensation of dizziness due to height. The reason for this I cannot explain, for I, like others when in a very tall building, looking down toward the ground, have an extremely giddy sensation.

During my three years in active flying I made in all about 2500 flights, flying in almost every city in this country and during this entire time I only met with one accident. Before a flight I absolutely assured myself that the machine was in as perfect condition as was possible, that the motor was delivering maximum power, etc. In the early days of flying the greatest source of trouble was the motor. Under the most favorable circumstances the motors only developed thirty-five horse power, and their life in the air was about twenty hours. I have many times had the experience while in the air of having an exhaust valve drop through the head of a piston and come out through the bottom of the crank case. In order to guard against such troubles it was always my policy to fly as high as possible, for in height there was safety. To explain the foregoing statement I will say that the gliding angles of these planes were about six to one; in other words, for one foot vertical drop of plane, you could glide in a horizontal direction six feet. By flying at a fairly good height of say approximately 2000 feet, this would mean that in case your motor stopped, if landing conditions were not favorable directly underneath, you could glide a distance of over a mile, and in this radius you could easily pick out favorable landing conditions.

One experience above all others will always remain vividly impressed upon my mind. This occurred in California in a flight from Venice to Long Beach, a distance across country of about twenty miles. Both towns are located on the coast. I had completed my exhibition in the former place and was flying my planes to Long Beach in order to be shipped East. The day was exceedingly foggy and the clouds hung at a distance of not over 1000 feet above the earth. As I knew the course well between these two points, I decided to mount above the clouds in order to strike better atmospheric conditions. My readers will understand that when I make the statement of flying above the clouds that under these conditions the earth is absolutely blotted from view. After flying for what I considered to be the proper time to cover the distance between these two places, I began to make my descent, and upon coming through the cloud banks I found that instead of being near Long Beach the wind had carried me over ten miles out to sea. Under these conditions I was absolutely at the mercy of my motor for if it had stopped at that time, there would have been nothing for me to do but make a landing in the water, and this would have been very serious as there is very little traffic along these shores. However in this case, as in many others, my motor power remained faithful to the last and I was able to reach shore without any further qualms.

The aeroplane of today has been refined in many details over the machines of five years past, as to workmanship, construction and to far superior motors. But as to the handling of the plane and as to the safety of the operator exclusive of the above features, no advancements have been made. This step however is bound to see the light of day within the near future, and it is my opinion that in the next twenty-five years, aviation will have advanced to a point where there will be comparative safety in the operation of aeroplanes.

SOME PHASES OF RAILWAY TRAFFIC STUDY WORK

By L. E. STIBBE, '15*

Synopsis: The method of taking and working up the data and the interpretation of the results of a street railway traffic study is described.

The profits of an electric road depend primarily on the effectiveness of its schedule. Especially is this true in the case of city lines where the income depends almost exclusively on passenger traffic, when it is necessary that the company conform in a sense to the movements of the people. The aim of the company should be to have only a sufficient carrying capacity at the proper place and at the proper time. The number of passengers carried per car mile should be a maximum, and this results directly from a proper schedule, which in turn can only be arranged with a thorough knowledge of the movement of the waves of people, their magnitude, and the time when such waves occur. More than this, the operation of a street railway system is a public enterprise, and due to this fact too, it behooves a company to strive to give complete and efficient service for other reasons than for personal financial gain. Operation in congested, or even frequently congested city districts, is subject to complications, remedies for which become almost imperative. It is acknowledged that for the arrangement and application of a satisfactory schedule, knowledge of details regarding the service and traffic conditions must be available, and this can best be obtained through observations and data taken in a thorough traffic study.

Traffice studies, therefore, should be conducted with a view toward determining if the public is realizing the best possible service, under the most profitable operation from the company's standpoint. The data should be sufficient to make it truly representative of all or many conditions of operation, and any results influenced by some unusual occurrence should be recognized and noted. Observations should not only be made throughout the entire day, but the study should extend over a period of time sufficient to include possible changes in business and weather conditions.

Different methods of obtaining data may be used. Observers may be stationed at some point of maximum loads along the route to record the loads on all cars that pass.

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* The General Electric Co., Schenectady, N. Y.

This method can be used only to find approximately how the loads occur and how they are being handled, and only on the more simple city lines. A more complete method is to ride on all the cars or on a representative car the entire length of its route, recording the changes in load at each stop, the character of the traffic, and all the conditions obtaining. Fig. No. 1 is a fac-simile of a data sheet with data taken by the latter method, which, as are also the figures following, is taken from the results of an extensive traffic study on one of the city lines of the LaFayette (Indiana) Street Railway system.

Referring now to Fig. No. 1, at the top is recorded some general data. In the ruled sections below is found the special data, which includes for one trip, "out" and "in," the number of people who get on or off at each stop, their classification, the time consumed at each stop,—taken with a stop watch,—the number standing in the car, and the total number of passengers being carried. The latter item is readily calculated after the trip is made. The number standing is taken so that if a few passengers usually stand by preference, the virtual capacity of the car may be taken, when considering overloads, as a certain percentage above its seating capacity. In the parenthesis are recorded the register readings at the end of the trip each way. These values, due to some children and so called deadheads riding, is usually smaller than the total number of people carried for the trip, and may be used to calculate a percentage of paying passengers.

The calculated values tabulated in the "Total On" column are the actual loads at points along the route, and taken collectively they show readily how the load on the car actually varied. The method in most common use for representing this variation is by the use of curves plotted with these values of load as ordinates, corresponding to points along the route as abscissae. Fig. No. 2 shows a so-called load-curve for one trip "out" and "in." Besides showing the general variation in load over the route, it is drawn to show the loads to be constant between stops and the change in load at each stop. The comfortable load line is drawn at the value of the virtual capacity of the car as calculated by the method explained above.

It is obvious that values for these load curves must be average values. If it is seen that the waves of traffic occur in a relatively similar way on certain days of the week, MARCH 6, 1915.

CAR NO. 226 OBSERVER L. E. S. TEMP.—30° F.
SHEET NO. 315 WEATHER—CLOUDY

START IN: 8:02 P. M. START OUT: 8.17 P. M.

(18) STOPS	OUT											(16) STOPS	IN										
	On	Men	Women	Children	Off	Men	Women	Children	Time	Standing	Total on		On	Men	Women	Children	Off	Men	Women	Children	Time	Standing	Total on
4—Main												4—Main											
3—Main												4—Col.											
3—Col.	2	1		1					6		2	3—Col.					5	1	2	2	9		0
4—Col.	2		1	1					5		4	3—Main											
4—Main	5	2	2	1					9		9	4—Main					5	2	3		8		5
5																	1	1			1		10
6	4	1	2	1					10		13												
Alley	1		1						5		14						3	2	1		6		11
7																							
8	1	1							$^1/_{40}$		15						3	1	2		3		14
9—Main	5	2	2	1					22		20						3	1	2		1		17
Columbia																	1		1				20
South																							
Wab.R.R.	2	1	1						5		22												
N. Stop.																							
S. Stop																							
Hitt																							
State																							
Crossing																					$^2/_1$		
Elliott					1		1		1		21												
9—Kossuth					5	2	3		9		16		13	4	9						21		21
10					3	1	1	1	3		13												
11					4	1	2	1	7		9		1	1									8
State																							
14																							
15					2		1	1	3		7												
16													2	2							5		7
18					1	1					6												
19																							
20					2	2			1		4												
21																							
22					2	1		1	2		2												
Main																							
24																							
Park Ave.													4	1	1	2					6		5
Loop					2		1	1	7		0		1		1								1

FIG. 1.

then data taken on these days should be grouped and averaged together. Again, it is reasonable to suppose that the traffic will vary according to a rule at the same periods of the days in any one group. Therefore, load values should also be averaged from data taken at the same hours. Consequently, a set of hourly load-curves should consist of one for each period of time embracing the time of the trip and there should be as many such sets as there are groups of days on which the traffic is held to be similar.

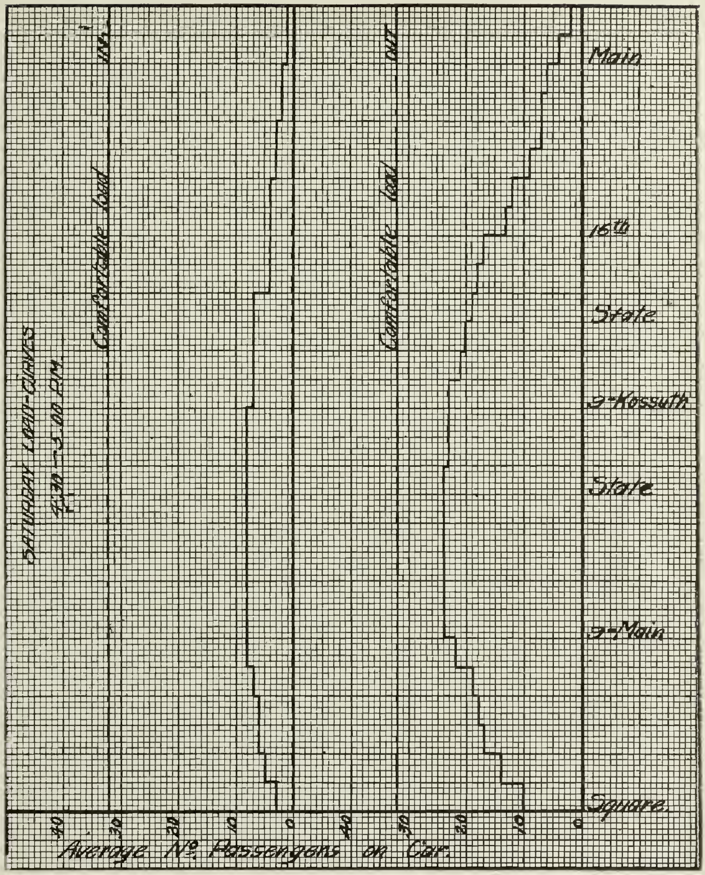

Fig. 2.

If a general average load-curve is desired representing all the days on which observations were made, values for it may be found by adding the loads realized at each point on the route for all the trips made and dividing by the number of trips. Or if values for the sets of hourly load curves have been found, these may be added for each point on the route, and the sum divided by the number of sets of curves being used.

The type of curves spoken of thus far are very good to depict conditions of traffic within the limits of the route and for any period of the day. However, besides knowing the variation in load within the time of the run or trip, and for a succession of consecutive trips, it is often desirable and interesting to know the variation of the maximum load with time, extending over a period of a whole day. To this end so-called all-day load-curves for any group of days may be drawn as shown in Fig. No. 3. These curves show the variations in the total number of people carried per trip. But similarly for a group of days they must represent average values and as such may be transferred from the highest point on each of the hourly load-curves already drawn. In a word, these curves show the total number of people riding "in" and "out" at all times of the day.

The first indication of an incompetent schedule and poor service is the existence of frequent and successive over-loads. From the company's standpoint unsatisfactory service is more quickly made evident by consistent zero-loads. The necessity for improvement as well as its possibility lies in the recurrence of these abnormal loads. The waves of heavy traffic that a schedule must sometimes be corrected to relieve are shown most readily on the all-day load-curves. Referring again to Fig. No. 3, they are seen to be of but short duration and may be accounted for in this case as follows: Workmen and clerks go "in" from 6:30 to 8:30 in the morning; clerks and business men go home at 12:00 M.; and some return about 1:00 P. M.; shoppers and clerks return home from 5:00 to 6:00 P. M., thus causing the only average over-load for the group of days that this curve represents; theatre goers and others go "in" about 7:30 P. M., and larger loads of the same go "out" after nine o'clock.

Cars are generally chosen to best suit the purposes which they will serve. They and their equipment are designed to give the most satisfactory service in their sphere of operation. For instance, the power and braking equipment on a car used in a congested business district must be such as to accelerate and decelerate the car quickly. More than this, the cars themselves may be designed to enable the passengers to move more advantageously, thus reducing the time of stop to a minimum, which in turn reduces the time necessary to complete a trip. To compare in this respect the use of cars of different designs, the data recorded on the time of stops is utilized. Thus it may be found that a single vestibuled Monitor type car may be much less efficient in handling passengers than the more recent P. A. Y. E. or Near Side cars or those with a center

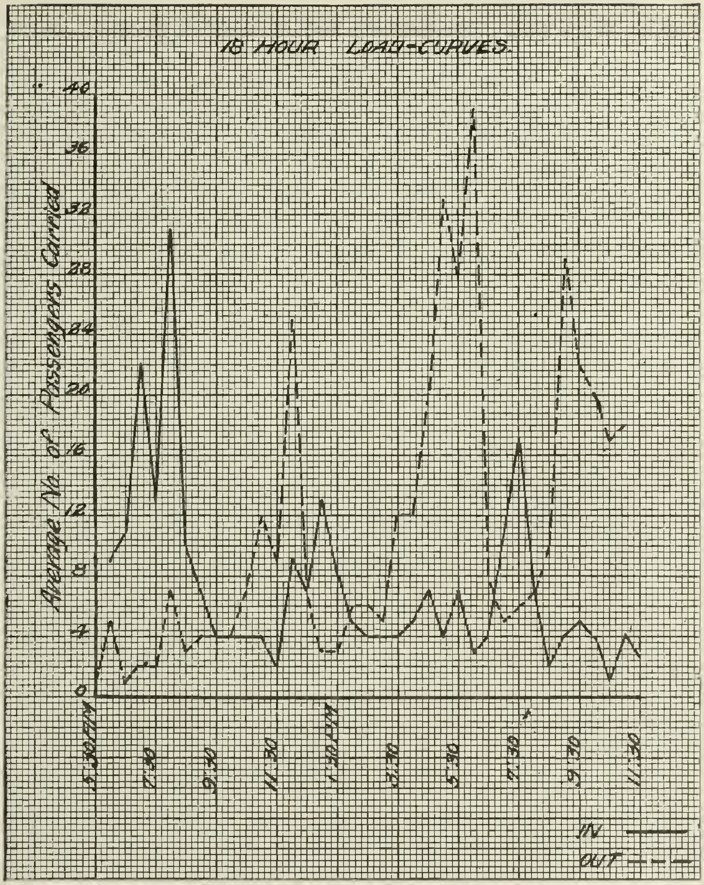

Fig. 3.

entrance or the double vestibuled type. To represent effectively the results on the time of stops there should be figured an average value per passenger of time in seconds required to board or alight for separate cases when different numbers of passengers get on or off.

The foregoing are the more important results and facts disclosed. Other things of more or less detail may be dwelt upon such as car heating and ventilation, courtesy of employees, convenience in placing cars, how the qualities of traffic affect the service, etc., suggestions for which develop out of the particular conditions and circumstances in hand.

The study in which the writer was interested, and from which the foregoing plates were taken, was made for ten complete days. The average maximum load "out" and "in" respectively during the whole period was only 40% and 25% of the comfortable load, and at no time was it seen advisable to lighten the schedule. The percentage of paying passengers for six of the ten days was 88% to 94% of the total number carried. Such statistics are perhaps not uncommon. Problems that confront officials of any public utility company are seldom comprehended by the complaining public which does not even realize that there is a limit to the distance a patron can profitably be carried for the customary five-cent-fare. Moreover, with the coming of the jitney in very recent years, electric railways have met a not only formidable but unfair competitor, and legislation will be gladly welcomed that puts these two operating companies on a more equal basis, sharing alike the expense and responsibility, as well as profits. Too often we find those who look defiantly at a needful corporation as if at the hand of an oppressor, and a more congenial and cooperative spirit can only be obtained through a more generally educated public.

IS THE ANSWER YES OR NO?

By F. F. CHANDLER, '99*

Synopsis: Mr. Chandler in this paper condemns the Public Service Corporations for not performing the service to the Public that their name implies and that their franchises require. As an example of a successful municipal owned utility, the small isolated power plants of Germany are cited, and the reason for their successful operation explained. It is claimed that Public Service Corporations in this country are in the hands of financiers, who manipulate them so as to yield large dividends to themselves, and the Public has to pay the bill. Prediction is made that this country is coming to municipal ownership.

This is not a love story or a novel with a detective sleuth plot, although it must be admitted that the caption has an air of mystery about it. But as the subject, itself, is more or less mysterious, it is felt that the caption is as good as any which could be selected. Like a great many citizens who live in any city large enough to boast of having Public Service Utilities, the writer has a suspicion that these organizations of capital are not really Public Utilities at all, but are in reality footballs in the scrimmage for wealth. What, in truth, is to be dealt with in this paper is therefore, "Shall we have municipal ownership?" Is the answer yes or no?

In any game of athletics the real way to become familiar with the feints of the adversary is to play the game against him. Feint is a good word. The dictionary says that it means pretense or mock attack, and mock attack means to pretend to do something which is not intended to be done.

Public Service Corporation is a phrase pleasing to hear. It is a good selection of words meant to carry a high toned thought, but let us see what the word "serve" means. "Serve" means to be subordinate or subservient to, to aid by good offices, to minister to the wants or well being of. We must, all of us, admit immediately that Public Service Corporations are not subordinate or subservient to the people. They do minister to the wants or well being of the people, but not in the big wholesome way that the word service implies. In short, they do not serve the public as well as they could and should do, and they therefore pretend to do something which they do not accomplish. This is a rather plain way of saying it, but just play the game against these adversaries for a while and you will find out that these statements are true.

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The writer does not mean that the people would be better off without these Public Service Corporations, because that would not be true. The fact is certainly appreciated that good light, good heat, good water, good transportation, etc., are all conveniences which every one is better off for having. It is found, however, that when our franchises are given up for these benefits, we still have to fight to get the benefits, and generally speaking, we have to pay more for them when we do get them than the same service is worth. It is felt that if the public only knew what the writer has learned from long contact with public utilities, they would vote for municipal ownership at the first opportunity.

Because a study of whether or not we should have municipal ownership is an interesting one and one which the readers of the Purdue Engineering Review, as engineers, should delight in, the writer wishes to point out some general facts in connection with the problem. It can be said of municipal ownership of Public Utilities that it has no reason to exist unless the people can themselves own and operate the utilities at a less cost than the price which they are compelled to pay when the utilities are privately owned. The problem therefore becomes this: Can utilities be operated more cheaply by the people? If they can, then the people will want municipal ownership. The writer believes that the answer is "yes" and that privately owned utilities, or a great many of them at least, could serve the public and more cheaply than they do. They will not do so, however, unless they are forced to it.

There are a great many items which have to be carefully weighed in this consideration. No particular problem will be taken up and analyzed carefully for you, but there are some pertinent facts, made by precedents which stand out strongly in favor of letting the people serve themselves.

Electricity, for instance, costs the people of Germany one-half of what it costs in this country. In Germany, this electricity is made with coal which costs four or five times what coal costs in this country and coal is next to the largest item in the cost of production. Labor is the item which comes next to coal. Labor is cheaper in Germany than in the United States but not enough cheaper to account for this great difference in the cost to the consumer.

There is a large loss in the transmission and transformation of electric current. It is surprising to know that such losses between the switch board and the customers' meters vary from 25% to 40%. In the great progressive metropolis of New York it is stated that this loss is 42%. This loss of current in this country is partially accounted for by the custom of building one large generating station and the consequent long transmission lines. Abroad, the generating stations are smaller and are larger in number. The building of these at logical distribution centers cuts down the transmission loss. Railroads find this same difficulty in handling cars in one large terminal. The cost per car is larger than if the terminals are smaller and more advantageously situated. Central station managers say that if the insurance companies in the United States would let them string their lines as they are permitted to string them in Germany, the line investment would drop. It is argued that if the lines in Germany are strung so cheaply and in a way so that the fire hazard is increased (as is claimed here) then the line losses in Germany would be greater than they are here. The comparative cost of current there is lower so that the argument does not "hold water."

In this country some of the board of underwriters have been guilty of conniving with central station interests and have passed rules and regulations which have favored Central Stations. These rules have been against the interest of isolated plants. Private plants to some degree carry out the economical divisional idea of generating stations which have proved economical in Europe. As the overhead charges of conducting central station business in this country is about two and one-half times the cost of producing the current, this, then, becomes the first place to criticise closely.

Even those items of overhead expense in Germany such as taxes, interest, insurance, salaries, etc., are no smaller in per cent than they are here. If this is true, then the present rate theories in this country are harmful as well as beneficial to the interests which use them.

While a large share of the overhead expense is made up of interest charges on watered stocks and bonds, yet there is also incorporated in the overhead expense a large item for advertising and for salaries of the solicitors who try to induce owners of isolated plants to shut them down. It costs money to do this and even if the plant is shut down it is often done at a rate so low that the price will not permit the rate to carry any proportion of the overhead expense whatever. A member of the Indiana Public Service Commission has admitted that such rates do exist. The result of this method of dealing loads upon the central station with more equipment, which costs money and which also calls for further watering of stock, puts the burden on the small consumer.

The above facts, which show that current is sold cheaper abroad than it is sold here, may leave you wondering where the real trouble lies. Abroad, the current is produced in a number of stations instead of one; the production costs less in spite of the high fuel cost; the line losses are less; the interest charge is less. Perhaps you do not know that in plants as small as 35 K. W. the coal needed amounts only to about one and one-half pounds per K. W. hour.

Look up what it costs here. In this country, central station engineers have admitted that they can not hope to compete with an isolated plant which has use for all its exhaust steam. Furthermore, exhaust steam will produce a ton of ice in 24 hours for every three engine horse power produced. Ice has been produced as a by-product in Central stations for 29c a ton. Roughly speaking, if central stations should go into the ice business, then privately owned ice plants would have no cause to exist and the price of ice would drop to 8 or 10 cents per hundred pounds including the delivery. What do you pay for ice?

Of course, this would mean a fight from the ice man, but you, as engineers, should interest yourselves in these things. You, as citizens, should interest yourselves in the juggling of securities as is carried on by the central stations. It is nothing short of criminal. Some day the people are going to settle this condition correctly.

The writer has no intention of fighting against privately owned utilities when they are properly conducted. But the Merchants Heat & Light Co., of Indianapolis, for example, started with about $275,000 in stock. They did not build much of a plant but used exhaust steam to good advantage. They grew into prominence on that account, attracting the attention of capitalists. Then came the usual issuing of preferred stock and bonds, which after all is only another way of borrowing money which a bank would not lend. Interest has been paid right along and this company now values itself at about $6,000,000. An interesting chapter in the career of this utility shows that in one transfer a very few men netted nearly $700,000. Its president is stated to have received $400,000 of this amount. His profit alone was about 150% of the original investment. The Indianapolis Water Company starting out with half a million dollars, has paid out dividends of $6,000,000 and has $8,000,000 left. The newspapers show these conditions to exist all over the country.

A good many cities now have most successful municipally owned plants. Anderson and Richmond in Indiana, Detroit and Cleveland have their own electric light plants, St. Louis and many other cities own their water works, and it would pay one to investigate their rates and earnings.

It is true that many places have shown failures but the cause has always been politics. Is there any less sense in having municipally owned water, light or ice plants or incinerators than there is in having municipally owned streets, sewers and fire protection? If you as engineers will look into the advantage which will come from the combination of plants, the result will be surprising. It is in this manner that the German industrial engineers gain prominence. There, they feel that if they take care of the pfennigs, the marks will take care of themselves, while in this country the financiers will take care of the millions if the "easy marks" will let them alone. The writer is not a socialist but he thinks he has a keen sense of justice.

In conclusion, the absolute prediction is made that we as a country are coming to municipal ownership. We are going to furnish ourselves with water, light, gas, ice and garbage and rubbish disposal and we are going to do it better and cheaper than it is now done. Are you as engineers preparing yourselves for it? If not, you are missing a big opportunity.

LOSS OF HEAD IN PIPES, BENDS, VALVES AND OTHER FITTINGS

By W. E. Stanley*

Synopsis: This article gives the results of an extensive series of experiments conducted in the Hydraulic Laboratory of Purdue University for the purpose of determining the friction losses in bends of various radii, and in valves of several types and at different openings. The apparatus and the method of conducting the tests is described in detail.

The flow of water in pipes is something with which almost every person is more or less acquainted, yet this very common action brings into existence many problems which have attracted the attention and taxed the abilities of some of the best hydraulic engineers and hydraulicians in the past.

One of the important questions in this connection is that of the quantity of energy necessary to overcome the frictional and other resistances to the flow in a pipe line. Many experiments have been conducted, both in the laboratory and in the field, upon pipes varying in diameter from 1-10 inch to 90 inches in the endeavor to establish the relation between the velocity of flow and the loss of head for that velocity. A large amount of data have become available from these experiments for the use of the engineer, from which he may estimate, with some degree of accuracy, the losses which will occur in the straight portions of a pipe line; but, as yet, data from which an estimate may be made of the losses due to the bends, valves and many other standard and special fittings to be found in any pipe line are extremely limited in both quantity and quality.

It is the object of this article to describe and present a few of the general results of an extensive series of experiments conducted from April to June, 1915, in the Hydraulic Laboratory of Purdue University, primarily to study the effects of bends of various radii, valves of several types and at different openings, and several standard and special pipe fittings. The experimental work was performed by the writer as a part of his graduate thesis and by Mr. I. Mazur, '15, who used the part pertaining to bends as an under-graduate thesis. All experiments were made on 1-inch pipe and fittings.

The pipe used was ordinary commercial black wrought-iron or steel pipe having an average internal diameter of 1.0306 inches, as determined from measurements by a vernier caliper at each end of all pieces used. The pipe line, as set up for testing, consisted of three experimental sections. The first section contained a bend and two tangents of straight pipe; the second section was 40 feet of straight pipe; the third section contained a valve and two lengths of straight pipe.

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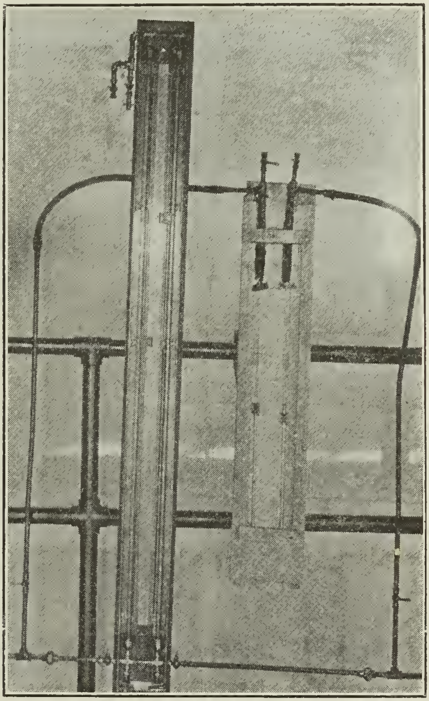


Fig. 1.

The loss of head through each section of the pipe line was obtained by either a water differential gauge or a mercury differential gauge (Fig. 1) connected by a ¼-inch wrought iron pipe to specialize piezometer rings at each end of the section. Losses of head for low velocities were determined by the water gauges while those for the higher velocities were determined by the mercury gauges. In a few cases, pressure gauges were used when the losses were beyond the range of the mercury gauges.

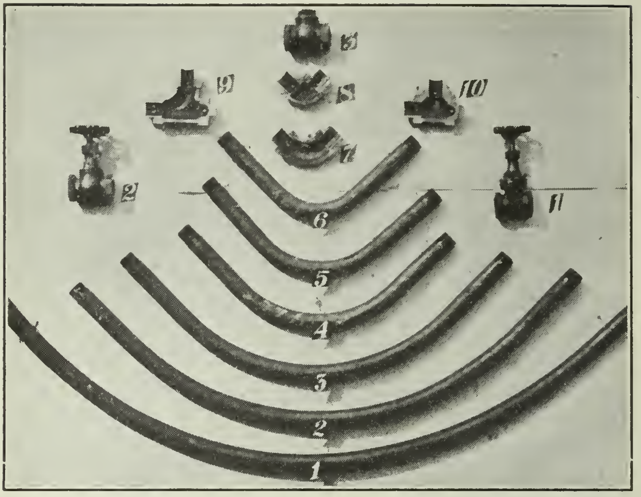


Fig. 2.

Tests were conducted on the bends, valves, and fittings shown in Fig. 2. Bends Nos. 1 to 6, inclusive, were made by bending to the proper radius lengths of pipe similar in character to the straight pipes. Bends Nos. 7 and 8, respectively, were standard "long turn" and "short turn" cast-iron 90° elbows. No. 9 was a standard cast-iron "long sweep special" tee, and No. 10 was an ordinary standard cast-iron tee. The valves were standard brass valves, No. 1 being a gate valve, No. 2 a globe valve, and No. 3 a check valve.

In conducting the experiments, the method used was such that simultaneous readings were taken over all three experimental sections, the gauges being located so that one observer could take care of the bend and the 40 feet of straight pipe sections while the second observer took care of the valve section and the weighing of the water used.

Twenty-five to thirty runs of three to ten minutes duration were made on each bend and for each valve setting, with velocities from 1 to 13 feet per second. After completing the experiments on the bends, valves and other fittings, the pieces of pipe forming the tangents in the bend and valve sections and the 40 feet of straight pipe section were all connected together making a straight length of 80.09 feet for which length a series of values for loss of head was determined. Altogether 514 runs were made, comprising approximately 18,000 readings of gauges and weights.

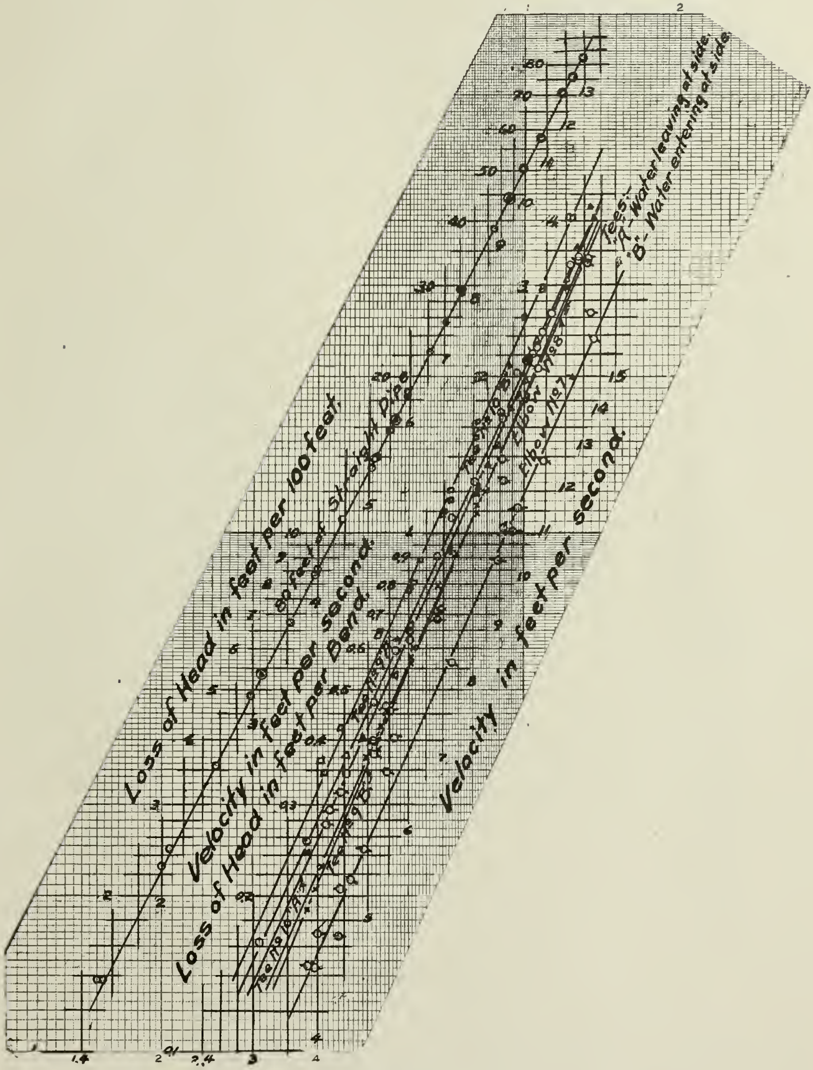

Loss of Head in feet per 100 feet.
80 feet of Straight Pipe
Velocity in feet per second.
Loss of Head in feet per Bend.
Velocity in feet per second.
Tees:- "A"- Water leaving at side. "B"- Water entering at side.
Elbow No 7
Elbow No 8
Tee No 10 "A"
Tee No 9 "B"
1.4
2
2.4
3
4

Fig. 3.

EFFECT OF STRAIGHT PIPE

The loss of head per 100 feet of straight pipe as determined by observing the loss of head over the 80.09 feet of straight pipe section is plotted in Fig. 3 as ordinates with velocity as abscissa. From these results it was found that the loss of head per 100 feet of straight pipe could be expressed by the exponential equation

$$h_l = 0.5965\, V^{1.925}$$

where h_l represents head lost in feet of water and V represents velocity of flow in feet per second.

EFFECT ON CURVATURE

The losses of head observed across the bend experimental section included the loss of head due to the friction in 20 feet of the two tangents of straight pipe, the loss of head due to friction in the bend and the loss of head due to the change in direction of flow. From the observed loss of head an amount was subtracted equal to the loss of head

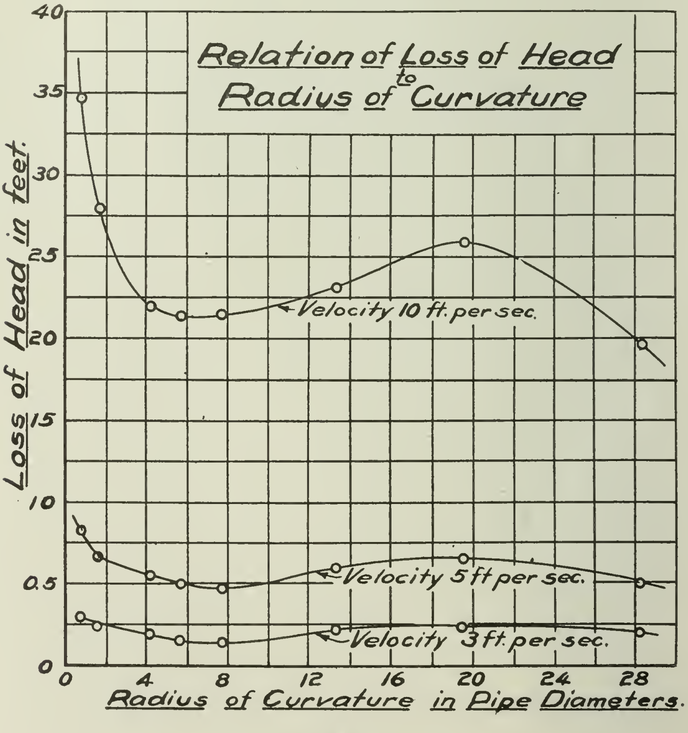


Fig 4.

which would occur for the same velocity in a length of straight pipe equal to the center line length of the bend section. The remaining quantity was the value of the excess loss of head due to curvature.

In Fig. 4 the curvature losses for velocities of 3, 5, and 10 feet per second are plotted as ordinates with the radius of curvature expressed in terms of pipe diameters as abscissae.

Fig. 4 indicates that the curvature loss is a minimum when the radius of curvature is 5 to 7 diameters, then reaches a maximum when the radius of curvature is about 20 diameters, beyond which point the loss decreases with increase of radius of curvature.

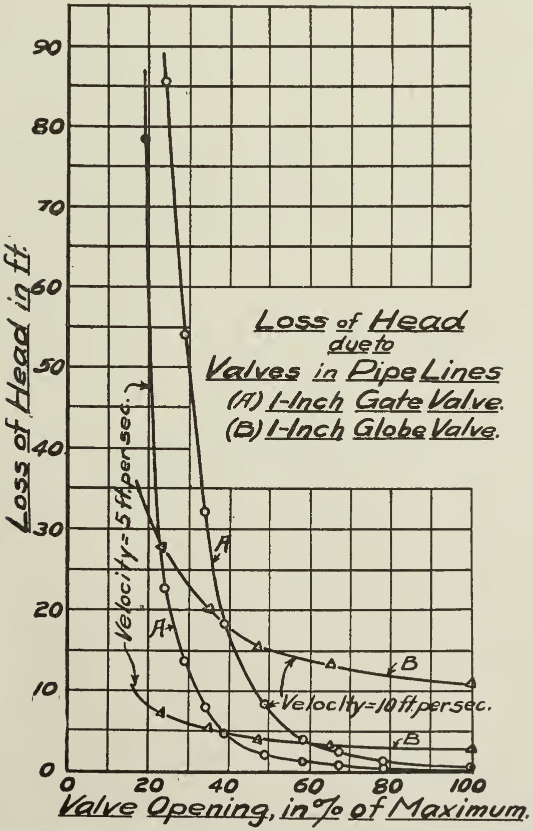


Fig. 5.

EFFECT OF VALVES

From the observed loss of head in the valve section, a quantity was subtracted equal to the loss of head in the 20 feet of the two lengths of pipe for the same velocity. The remaining quantity represented the loss of head due to the valve in the pipe line.

In Fig. 5 the losses in the gate and globe valves for velocities of 5 and 10 feet per second, obtained in the above manner, are plotted as ordinates with the valve opening expressed in per cent. of the maximum opening as abscissae.

From Fig. 5 we see that closing a gate valve does not greatly increase the resistance until it is 40 per cent. closed for a velocity of 10 feet per second or 60 per cent. closed for a velocity of 5 feet per second. The loss caused by a globe valve is much greater than that caused by a gate valve for wide open valves, but does not increase greatly until the valve is more nearly closed.

In Table A are tabulated the lengths of straight pipe which would give the same loss of head as obtained in the above manner for the gate and globe valves wide open and for the check valve with the check in place and with the check removed.

The loss of head in a gate valve wide open as compared to the loss of head in straight pipe decreases with an increase of velocity, while for the globe valve wide open and the check valve, the ratio increases with an increase of velocity.

From the last column in Table A, we find, for an average, that a gate valve is equivalent to about 8 diameters of straight pipe and that the globe valve wide open and the check valve are each equivalent to about 25 diameters of straight pipe.

EFFECT OF STANDARD ELBOWS AND TEES

If from the observed losses across the bend section the loss of head due to the 20 feet of the two tangents of straight pipe be subtracted the remaining quantity will be the value of the total loss of head due to the bend.

By inserting 90° elbows and tees instead of the bends the total loss of head caused by the elbows and tees was determined in the above manner. These total losses were plotted in Fig. 3 as ordinates with the velocities as abscissae.

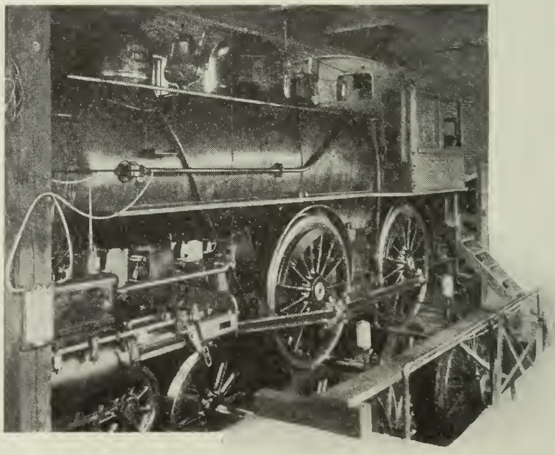
TABLE A—EQUIVALENT LENGTH OF STRAIGHT PIPE FOR LOSS OF HEAD IN VALVES AND STANDARD FITTINGS.

Velocity, feet per second		12	10	7	5	3	
Str. Pipe Loss per foot, feet		0.714	0.502	0.252	0.132	0.059	Avrg.
Gate Valve, wide open	Valve loss, feet	0.36	0.28	0.18	0.13	0.04	
	Equiv. length of Str. Pipe, in. feet	0.504	0.557	0.715	0.985	0.810	0.714
	Equiv. length of Str. Pipe, in. Pipe Diam.	5.9	6.5	8.3	11.5	9.4	8.3
Globe Valve, wide open	Valve loss, feet	15.60	10.80	5.32	2.76	0.96	
	Equiv. length of Str. Pipe, in. feet	2.19	2.15	2.11	2.09	1.96	2.10
	Equiv. length of Str. Pipe, in. Pipe Diam.	25.5	25.1	24.6	24.4	22.8	24.5
Check Valve	Valve loss, feet	16.30	11.30	5.58	2.88	1.02	
	Equiv. length of Str. Pipe, in. feet	2.28	2.25	2.21	2.18	2.08	2.20
	Equiv. length of Str. Pipe, in. Pipe diam.	26.2	25.9	25.4	25.1	24.1	25.3
Check Valve, check removed	Valve loss, feet	14.20	9.91	4.91	2.54	0.89	
	Equiv. length of Str. Pipe, in. feet	1.99	1.97	1.95	1.92	1.82	1.93
	Equiv. length of Str. Pipe, in. Pipe Diam.	22.9	22.7	22.5	22.1	21.0	22.2
St'd "Short Turn" 90° Elbow	Elbow loss, feet	2.75	1.80	0.795	0.370	0.115	
	Equiv. length of Str. Pipe, in. feet	3.85	3.59	3.16	2.80	2.35	3.15
	Equiv. length of Str. Pipe, in. Pipe Diam.	44.8	41.8	36.8	32.6	27.4	36.7
St'd "Long Turn" 90° Elbow	Elbow loss, feet	1.79	1.19	0.536	0.253	0.081	
	Equiv. length of Str. Pipe, in. feet	2.51	2.37	2.13	1.92	1.65	2.11
	Equiv. length of Str. Pipe, in. Pipe Diam.	29.2	27.6	24.8	22.4	19.2	24.6
St'd C. I. Tee, water leaving at side	Tee loss, feet	3.06	2.01	0.894	0.421	0.134	
	Equiv. length of Str. Pipe, in. feet	4.29	4.00	3.55	3.19	2.74	3.55
	Equiv. length of Str. Pipe, in. Pipe Diam.	50.0	46.6	41.3	37.2	31.9	41.4
St'd C. I. Tee, water entering at side	Tee loss, feet	3.80	2.52	1.12	0.530	0.169	
	Equiv. length of Str. Pipe, in. feet	5.32	5.02	4.44	4.02	3.45	4.45
	Equiv. length of Str. Pipe, in. Pipe Diam.	62.0	58.5	51.7	46.8	40.2	51.8
St'd C. I. "Long Sweep Special Tee," water leaving at side	Tee loss, feet	3.07	2.05	0.934	0.451	0.148	
	Equiv. length of Str. Pipe, in. feet	4.30	4.08	3.71	3.42	3.02	3.71
	Equiv. length of Str. Pipe, in. Pipe Diam.	50.1	47.6	43.3	39.9	35.2	43.2
St'd C. I. "Long Sweep Special Tee," water enter'g at side	Tee loss, feet	2.82	1.82	0.795	0.359	0.108	
	Equiv. length of Str. Pipe, in. feet	3.95	3.63	3.16	2.72	2.20	3.13
	Equiv. length of Str. Pipe, in. Pipe Diam.	46.0	42.3	36.8	31.7	25.4	36.4

The loss of head for velocities of 12, 10, 7, 5 and 3 feet per second was taken from Fig. 3 and tabulated in Table A. By dividing these losses by the loss of head per foot of straight pipe as determined by the 80.09 feet of straight pipe experiments for the same velocities, the equivalent length of straight pipe in feet was found. Dividing the value of feet of straight pipe by the average pipe diameter (1.0306 inches), the equivalent length of straight pipe in terms of pipe diameters was obtained, thus making the results comparable with results which may be obtained from pipe fittings of different diameters.

From Table A and Fig. 3, it is seen that the loss of head through the elbows and tees increases with a greater power of the velocity than does the loss of head through the straight pipe. Also from Table A, it becomes quite evident that the "long turn" elbow should be used in preference to the "short turn" elbow where the loss of head is an important consideration in the design of a pipe line.

Considering the tees, Table A and Fig. 3 show that with the ordinary standard tee the loss of head is less if the water leaves at the side than if the water enters at the side, being equal in the former case to that due to 30 to 50 diameters and in the latter case to that due to 40 to 62 diameters of straight pipe. With the "long sweep special" tee the opposite condition is found. In the case of the water leaving at the side the loss of head is equal to that due to 35 to 50 diameters of straight pipe, while in the second case the loss is equal to that due to 25 to 46 diameters of straight pipe.



Locomotive Testing Laboratory, Purdue University.

MODERNIZING A BOILER PLANT

By W. A. HANLEY, '11*

Synopsis: This article tells in detail how a small isolated boiler plant of approximately 700 boiler horsepower was enlarged and modernized so as to bring about a decrease in coal consumption of 22% and yield an interest of 33.5% on the investment necessary to produce the economies.

In undertaking the improvement of a boiler plant, the local conditions as to nature of service required, available equipment at hand, space for new equipment, coal supply, etc., are all factors which must enter into the final conclusion. That additional capacity was necessary, and that a saving in both labor and fuel could be made at the Indianapolis plant of Eli Lilly & Company, had been apparent for some time, and in the fall of 1912 the matter was taken under investigation.

The problem at hand was to supply 250,000 pounds to 350,000 pounds of saturated steam per day, with a maximum demand of 30,000 pounds per hour, not falling below 15,000 pounds per hour except at night, at a pressure of 120 pounds gauge, from 200 degrees Fahrenheit feed water. This steam was to be used for all general purposes throughout the plant, about 40 per cent. being taken in the central power house for generating electricity, compressing air, pumping water, etc., and 60 per cent. in heating, evaporating, drying and other processes throughout the laboratories.

The equipment at hand consisted of two type E–200 H. P. Stirling boilers in one battery, and a single unit of 300 H. P. of the same make and type. These boilers were connected into a brick lined steel stack 6 feet in diameter and 113 feet high, and were each equipped with an American Underfeed Stoker. Forced draft from an engine-driven fan was also piped under each furnace. An open type heater, hot water softener, and two boiler feed pumps were all found in good condition and of ample capacity. Nut coal from eastern Kentucky, having the same general characteristics as Pocahontas, and having a fuel value of 13,500 to 14,000 B. t. u. per pound, at a cost of $2.70 per ton delivered in front of boilers, was being used. The boilers were clean, settings tight, appliances in very good condition, and no local wastage of steam or coal was evident. Coal was hauled direct from cars or from storage yard in wagons, and was unloaded by hand into bins in boiler room, from where it was shoveled into hoppers of stokers. Ashes were dragged out from under boilers onto boiler room floor, and wheeled in barrows to alley adjacent to boiler room, where they were dumped. From this point they were reloaded into wagons and hauled to trash dumps.

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* Mech. Engineer, The Eli Lilley Co., Indianapolis, Ind.

The installation of a daily log, showing pounds of coal delivered to boiler room, number of boilers under fire, load variation, etc., was accomplished. At the same time a combined indicating and recording venturi meter was installed on the boiler feed line, and figures ascertained as to repairs and labor. Tests under operating conditions, over 8-hour and 10-hour periods, following the A. S. M. E. code, using a throttling calorimeter, and weighing the water and coal were then run on each of the three boilers, and on the boilers in pairs as they were operated. At the same time the venturi meter was checked and found to be correct to within 4 per cent. under extreme conditions of variation.

The tests and records showed the following to be true:

1st. That the boilers could not be operated above 95 per cent. of rated capacity.

2nd. That the fuel cost averaged 15.68 cents per 1,000 pounds of water evaporated under operating conditions.

3rd. That owing to limited capacity the 300 H. P. boiler must be in constant use, except on Sundays, and an accident to same would mean closing part of the plant.

4th. That owing to the absence of railroad switching facilities and a prohibitive cost to install same, the cost of handling coal could not be decreased.

5th. That the cost of handling ashes could be materially reduced, and a large part of the energy used to drive stokers and draft fan could be saved.

6th. That cost for repairs had not been excessive and could not be lowered an appreciable amount.

With the above facts well established it was therefore determined to install such equipment as would give additional boiler capacity, lower evaporation cost for fuel, lower ash handling costs, and reduce the energy consumed in stoker and fan drives.

An addition was made to the boiler room of sufficient size to accommodate a battery of type L-16 312 H. P. Stirling boilers, and one-half the battery, that is, one boiler of 312 H. P., was installed. As Indiana screenings offered the greatest number of available heat units for the least amount of money, and as satisfactory guarantees both as to efficiency and capacity could be obtained from reliable stoker companies, it was decided to use such fuel.

A contract was made with the Green Engineering Company, of Chicago, Illinois, to remove the old stokers and install chain grate stokers and high pressure water backs on each boiler, remodel and re-line the furnaces, rebuild the fronts of boilers, construct an ash tunnel under boilers, and install a bucket ash conveyor and ash bin at the end of boiler room. Their contract also covered the installation of a drive for stokers and the brick work and breeching connection on the new type L-16 Stirling boiler. Practically the entire work and all details were covered in this contract except steam and water piping and electrical wiring. All the work had to be done without interfering with the operation of the plant, and the work under boilers as to tunnel, et., was accomplished while the boilers were under fire.

The concrete tunnel under boiler room was made 8 feet wide and 8 feet high. The ash pits were made exceptionally large. A dumping ash cart on a narrow gauge track passed in front of the ash door under each boiler. The track terminated in a boot at the end of boiler room, where the ashes were dumped and hoisted to the ash bin outside the building. This bin was of sufficient capacity to carry three days' supply of ashes and was elevated so that wagons could drive under same and load by opening a gate in bottom of bin. The ash tunnel ceiling carried the shafting for driving the stokers. The stokers were driven by two units both located on boiler room floor, one being a 7½ H. P. 50 per cent. variable speed motor and the other a 5″ x 6″ vertical steam engine. As a matter of safety it was considered necessary to install two units, and as electricity was not available on certain nights and Sundays it was necessary to install the engine, the motor being used under all other conditions.

The furnaces were reconstructed and made of the Dutch oven type with deep ignition arches, and the high pressure water backs were made of extra heavy 5-inch pipe and equipped with GECO fittings. Ample provision was made under the furnaces for the recovery on boiler room floor of droppings from grates. The ash conveyor was driven by a 5-inch by 6-inch vertical steam engine, being the same size and type as the auxiliary stoker drive. As ashes were to be handled at night, electricity would not be available for driving a motor at that time. The breeching to the new boiler was made as large and with as wide sweep bends as possible.

The guarantees as set forth in the contract with the Green Engineering Company are quoted below as follows:

"The contractor will give guarantee the following results, when furnished with coal of at least 10,000 B. t. u. and a draft of not less than 3-10 inch of water in the furnace over the fire:

(1) To maintain an efficiency of approximately 68 per cent. under operating conditions, the stokers being fired under contractor's instructions.

(2) To obtain an overload capacity of 30 per cent.

(3) To eliminate smoke so as to conform to the Indianapolis smoke ordinance.

(4) That the cost of metal repair parts for stokers will not exceed $20.00 per stoker per year for a period of 3 years, and that the metal repair parts purchased will not cost to exceed $50.00 per ton."

In order to obtain the required draft it was found necessary to increase the height of the stack by 50 feet, making it 163 feet high. This was done by another contractor with the stack in constant use, after some preliminary work had been done as follows: On the first Sunday the ornamental top and water table were removed, on the second Sunday a six-foot steel section was added with an opening in the side of same to allow smoke to escape, and on the third Sunday another six-foot section was added with a steel plate in bottom of same thus closing completely the top of the stack. Thereafter the work was carried on with the stack in use, and when the full 50 feet had been added, the sheet closing the top, above referred to, was removed and the side opening covered.

To complete the entire installation of new stokers, etc., required a period of about six months. At the end of such time an acceptance test, under ordinary operating conditions, was run on each boiler. With Indiana screenings of about 11,000 B. t. u. per pound an overall efficiency of 70 per cent. was obtained, and a capacity of 75 per cent. overload developed on each boiler.

In order to determine what coal could be used most economically, a series of ten steaming tests, under operating conditions, covering periods of 6 hours to 10 hours were made, using various grades of Indiana and Illinois screenings. A careful comparison showed that coal furnished by the Garstang Fuel Company, of Indianapolis, Indiana, and mined by the S. W. Little Coal Company, of Evansville, Indiana, by analysis and by test should be used. Some better and some poorer grades of coal were tested, but at relatively higher prices. The general characteristics of this coal from a large number of analyses made in our own laboratories at different seasons of the year shows it to be as follows:

1¼ inches Nut and Slack coal from No. 5 vein, Pike County, Indiana.

V. C. M.	25.86 per cent.
Fixed Carbon	48.98 per cent.
Moisture	11.58 per cent.
Ash	13.58 per cent.
Calculated value B. t. u. per lb.	11,270

Statistics for the first year after this installation was complete showed that 91,775,000 pounds of water had been evaporated, at a fuel cost of 12.21 cents per thousand pounds, which represented 3.47 cents saving per thousand pounds or a total of $3,183.90 on fuel alone. In addition to the above the savings in labor for hauling and handling ashes were $140, and the saving in steam for fan and stoker drives $200, making a total return from the investment of $3,523.90 for the year. Repairs have been very little, but no actual saving can be counted on this item as the same may increase with the age of the installation. The total expenditures for building, boilers, stokers, stack, and equipment represented about $25,000. Of this, $14,500 was spent to increase capacity and $10,500 to produce economies. The gross return, therefore, of $3,523.90 per annum on the $10,500 expenditure represented 33.5 per cent.

The boilers have been operated at from 50 per cent. to 75 per cent. above capacity at all times, as this has been found to be most economical. No delays or failures in service have been experienced, and the smoke ordinance has been fully complied with.

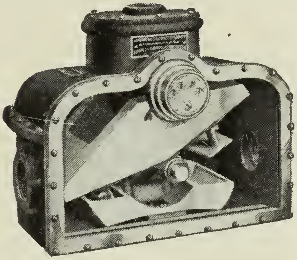
CONDENSATION METERS

By W. T. Miller, '16

Synopsis: Three methods of metering steam heat to consumers of central station heat are explained. The condensation meter is rapidly replacing other methods and is giving very satisfactory service. These meters are of two types: the weight and the volumetric. The operation, care, faults, and advantages of each are discussed in this article.

The most important phase of central station steam heating work is selling heat. There are in common practice today two methods of disposing of the product; the flat rate, based on square feet of radiation, and, a schedule rate based on the actual amount of steam condensed in the particular system.

In the younger days of central station steam heating, it was realized that the logical way to sell service was to base the rates upon actual consumption, but the methods of measuring the quantities of steam supplied to various customers were very crude and led to unwarrantable errors. The difficulty experienced in determining a fair approximation at the steam supplied, led to the adoption of a flat rate which was originally based on the cubical contents of the building to be heated. This method made no allowance for the exposed walls, window or glass surface and proved unsatisfactory because of this fact. The original flat rate evolved into a rate based on the number of square feet of radiation installed. The rate per square foot was based on an assumption as to the quantity of steam condensed per square foot per season. As exposed wall and glass areas were considered when the number of square feet of radiation was computed, this method of determining the rate was fairer to the consumer and producer than the earlier one. However, there is a personal element which entered into the problem in that some consumers through carelessness may cause the rate of condensation per square foot of radiation to rise a considerable amount above that upon which the rates were based. Again, a careful customer might cause the rate of condensation to become considerably lower than that for which he was paying. While the average may be near the rate assumed, the careful customer was paying for the negligence of the other. In order to eliminate this fault, the greater number of companies are at the present time adopting a schedule based on the actual amount of steam supplied to each individual consumer. This scheme has been made possible by the perfection and simplification of devices for measuring the flow of steam and condensation.



Dump Bucket Type Meter.

There are several meters on the market designed to measure the flow of steam. These meters are, by merit of their fundamental principles, divided into two classes; those depending upon a constant velocity of steam, and those based on a constant supply area. Meters of both types have been perfected but are necessarily of a rather delicate construction; this means that they are somewhat costly and that they require considerable attention. These facts limit their general use to power plants and large consumers of steam, since the initial cost and cost of maintenance prohibits them from being supplied to numerous small consumers.

The condensation meter solves, to a great extent, the problem of providing a cheap and sufficiently accurate means of measuring the steam supplied to small consumers. Since the perfection of this type of meter, the central station steam heating industry has made its greatest strides. Condensation meters are primarily gravity meters and cannot discharge against pressure. Three principles of operation are incorporated in the condensation meters commonly used by central station heating companies; those that are based upon volumetric measurement, those that record the weight of fluid passing through it, and those that are based on the trap principle. Of these types the volumetric and weight meters are the most common due to their simplicity. Perhaps the most common of the weight meters is the Simplex, while the most popular of the volumetric meters is the Detroit.

The Simplex meter is of the dump bucket type, and has two buckets balanced on a shaft which rocks as they alternately fill and dump. The condensation enters into a receiving chamber where the stream is divided by means of a baffle plate in order that the velocity may be diminished. From the receiving chamber the condensation passes through a nozzle and flows in a thin stream into the main chamber of the meter where the partition between the buckets deflects it into the bucket that is being filled. As the bucket fills, the increase in weight causes it to overbalance the empty bucket and it falls into a position that permits the condensation to flow into the bottom of the main chamber from which it is drained through an outlet at either end. A plunger is attached to the bottom of each bucket which fits into a corresponding dash pot fixed to the bottom of the meter. These dash pots are filled with water at all times and the cushion action tends to make the action of the meter noiseless. A set screw is provided by means of which the travel of the buckets may be regulated, thereby controlling the capacity of the buckets. A revolution counter records the oscillations and reads in pounds of condensed steam. The shaft is supported at each end by means of bronze cones and cups in which bronze balls are used. The bearings are supported in removable caps attached to the meter case. These meters are calibrated to operate at a temperature of about 180 degrees F. The error involved at rated capacities is very small but the impact effect of the condensation entering the buckets causes a noticeable error when the meter is operated at overloads and at exceptionally light loads.

The Detroit meter is of the revolving drum type, and its mechanism consists of a cylindrical copper drum which is divided into six scroll shaped compartments. A brass spout which is attached to the meter case but not to the drum admits the condensation. In the bottom of the spout and extending its entire length is the inlet opening through which the condensation is admitted in a thin stream to each compartment of the drum as it rotates. Due to the shape of the compartments and to the fact that any one compartment cannot fill and discharge at the same time, any change in the volume or velocity of the incoming condensation cannot affect the discharge and consequently cannot affect the accuracy of the meter. The compartments are exactly the same size, and as each receives and discharges the same volume of water at each revolution, the same quantity of condensation passes through the drum at each revolution. When the inflow of water stops, the motion of the drum ceases and the water in the compartments remains there until the flow is resumed. The drum is made of sheet copper and is very rigid in construction. The bearings which support the drum consist of hard bronze flanges which are soldered to the drum. These flanges are supported by bronze rollers held in cast bronze brackets mounted inside the cast iron casing. The registering device consists of a clockwork revolution counter which reads in pounds of condensation per revolution. The clockwork is protected by a glass dial and is enclosed in a housing that is cast integral with the casing. The meter is calibrated for a temperature of about 140 degrees F. and is accurate with 1% at all loads. This meter is adapted to vacuum service when used in connection with a vacuum trap.

The faults to be found in the operation of condensation meters are usually due to lack of care in their installation and maintenance. As condensation meters are more apt to read under than over, it is to the interest of the operating companies to maintain a rigid system of maintenance and inspection. All meters should be overhauled, cleaned and calibrated at least once each year.

Perhaps one of the most serious handicaps on hot water central station heating is the fact that no suitable means of metering the heat has been perfected. Devices for registering the comparatively small differences in temperature and pressure would be necessarily very delicate and hence too costly to warrant an elaborate installation. Could a simple and hardy device be perfected to register these differences, the results might be more satisfactory than those now obtained through the use of condensation meters in the steam systems, as the chief objection to their use is that the condensation may be diverted or lost before it reaches the meter.

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The Purdue Engineering Review

No. 12 PURDUE UNIVERSITY May, 1916

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The splendid support that the Alumni of Purdue University are giving to the *Review* is reflected very well by the list of contributors to the publication this year. Never since the call has been made for papers has the response been more prompt and the material so plentiful, and it is with distinct regret that we are unable to publish all the good articles that were offered us this year. When so many busy men, who are constantly being pushed by the cares and responsibilities of business, as many Purdue men are, offer to take the time and go to the trouble of working up a paper for publication in the *Review,* we feel decidedly encouraged and feel that the Alumni body in general appreciates the work that the *Review* is doing and the place that it is trying to fill.

The *Engineering Review* is the journal of the Engineering Societies of Purdue University. It is published by their *Board* for the purpose of advertising Purdue and the kind of work that Purdue men are doing as engineers in different parts of the world. The publication reaches the members of the Engineering Societies of the Central and Middle Western States, the engineering students of several of the leading technical universities, in addition to several hundred business firms in all parts of the country.

Department Notes

SCHOOL OF ELECTRICAL ENGINEERING

PERSONNEL

Little change has been made in the staff of the School of Electrical Engineering during the past year, as the organization for the year 1914-15 was considered to be a particularly strong one. One assistant, Mr. G. C. Blalock, was added to the corps making a total of thirteen. Mr. Blalock is a graduate of the University of Michigan in Electrical Engineering and since graduation has obtained some valuable experience on the Electrical Engineering staff of the Municipal Board of the city of Los Angeles, California. Professor A. N. Topping, who for a number of years has been in charge of the Junior work and specialized work in illuminating engineering, has been made full professor of Electrical Engineering. Professor Alfred Still is now professor of Electrical Design. Mr. D. L. Curtner has been advanced from the grade of assistant to that of instructor during the past year.

Professor C. Francis Harding, head of the school, has continued to act during the year as chairman of the subcommittee on Technical Education of the National Electric Light Association and represented the Indiana Engineering Society at the recent conference of representatives of State Engineering Societies, looking toward closer co-operation between such organizations.

CHANGE OF COURSE

Some marked improvements have been made in the course in Electrical Engineering during this year, involving the completion of the work in mathematics at the middle of the Junior year, thereby permitting more work in applied Electrical Engineering to be administered to Juniors. The Senior course in Corporate Organizations which offers training in the organization, management and financial relations of corporations will be required work for the second semester during the coming year while the elective courses will be confined to the first semester of the Senior year.

RESEARCH

A large amount of research work has been carried on during the past year in the School of Electrical Engineering, particularly with regard to the testing of very high voltage insulators and interference between high voltage lines and parallel telephone lines. The latter problem, which is becoming of much practical importance with the increase in the number and voltage of transmission lines, is being studied with respect to both the experimental line at the University and some long transmission lines in practical operation. The results of this work together with that in the electric railway field are being published in the proceedings of the various engineering societies and in the technical press.

SCHOOL OF CIVIL ENGINEERING

PERSONNEL

The resignation of R. L. Sackett, who is now Dean of the Engineering Schools at Penn. State College, was regretted by the faculty of the School of Civil Engineering. Professor Sackett's work is being cared for by Professor Wiley and Mr. Greve, assisted by Mr. C. C. Brown, a practicing engineer and also Editor of Municipal Engineering at Indianapolis. Mr. Brown was formerly Professor of Civil Engineering at Union College, Schenectady, N. Y., and consulting engineer for the New York State Board of Health.

Mr. R. C. Pierce, graduate of the University of Illinois, and formerly with the Reclamation Service, was appointed Instructor in Civil Engineering.

LABORATORY FOR TESTING MATERIALS

Professor Scofield has installed a special testing apparatus for determining the most efficient design of reinforcing material for concrete roads. A slab is uniformly loaded with a testing pad under air pressure, and the consequent deformation and deflection throughout the entire slab are measured.

Professor Martin has determined the flexural strength of road sections made up of a concrete base with a brick top as compared to a solid concrete road.

Professor Albert Smith has continued his painstaking investigations of the distribution of stresses throughout riveted steel joints to determine the slipping point of the rivets and the proportionate share of the load carried by the various rivets. In this work the deformation throughout the entire joint is indicated by the rotation of small mirrors.

Professor Scofield in co-operation with Professor Wallace of the School of Mechanical Engineering, has been investigating the strength of side frames for railway cars. A survey of the deformation is made throughout the entire side frame with a view to economic design.

The laboratory has rendered service to the Indiana Sand and Gravel Producers' Association by determining the most efficient division plane between the fine and coarse aggregates, screened from gravels for use in concrete. The present practice calls for this division between sand and gravel on a sieve with ¼-inch openings. It has been determined that a screen with ⅛-inch openings will yield as strong a concrete in many cases and will make use, without waste, of nearly the entire output of the gravel beds as found in many places in Indiana. In conjunction with Professor Peffer of the School of Chemical Engineering, a series of tests is under way to discover the most efficient materials with which to protect concrete against disintegrating agencies.

HYDRAULIC LABORATORY

The determination of the loss of head due to the flow of water through one-inch straight pipe, elbows, bends, valves and special fittings has been completed. The investigation is being continued during the present year on 1½-inch pipe by Mr. Greve and Mr. Stanley.

TOPOGRAPHICAL ENGINEERING

For the first time, the School of Civil Engineering has taught the elements of the use of the transit and level in marking out straight and level lines to Juniors in the School of Mechanical Engineering. These exercises are a portion of the course in Junior Laboratory. The student reports for five afternoons during the semester. It is not expected that these men will obtain competency in the use of the instruments in field work of civil engineering. They will be able to lay out factory buildings, foundations and line up shafting.

The Engineering Camp for the summer of 1915 was held at Pentwater, Michigan, from May 29 to July 3. Pentwater is a town of about 1,200 inhabitants on the east shore of Lake Michigan, about 270 miles north of Lafayette. The camp was attended by sixty-five students, five instructors, one janitor and three cooks. The cost for board and lodging approximated $5.00 per week. The entire cost to each student was less than $40.00. Last year's success has led to arrangements for the 1915 camp at Pentwater for a period of six weeks. The school is considering plans for a permanent surveying camp on land owned by the University on which a permanent building can be erected.

HIGHWAY ENGINEERING

Professor Martin has held one district road school, and four county road schools in the State, each one attended by over fifty persons, together with about fifteen community meetings. Continued service has been given to road officials in advice upon road problems. Several field experiments in road building are under way in co-operation with the U. S. Office of Public Roads. Professor Martin has published one bulletin on road maintenance, and two leaflets on gravel roads and the use of the road drag. The official state road school was unusually successful this year, being attended by over sixty state officials. The School of Civil Engineering is serving the State of Indiana in a thorough way in Highway Engineering.

SCHOOL OF CHEMICAL ENGINEERING

This school has enjoyed a year of very satisfactory growth, characterized by such a heavy demand for the services of graduates that only a portion of the available openings could be filled.

The new plan of administration of mathematics for the engineering schools, whereby the latter subject is completed in the first semester of the Junior year, has permitted of the further improvement of the curriculum of this school by the introduction of a course in Physical Chemistry in the Senior year.

During the year additional work has been done along the line of investigating the action of organic acids and salts on concrete, as well as on methods for the measurement of film thickness of lubricating oils. Other work in progress at the present time consists in an investigation of the effect of various substances on the setting time and other properties of finely ground cement clinker, also a survey of the combustion conditions in a boiler furnace.

SCHOOL OF MECHANICAL ENGINEERING

A brief account of the year's work in the Department of Mechanical Engineering for the past year may be summarized under four heads:

PHYSICAL GROWTH

During the year the department has had the temporary use of $1400 worth of apparatus. New equipment to the value of $2360 has been added to laboratory apparatus, while friends of the University have made unsolicited donations of $2900 worth of valuable equipment either for test, exhibition or routine laboratory work.

RESEARCH

Fifteen lines of research were completed far enough to be worthy of publishing, while twenty problems are still under investigation. The value of the research work is increasing each year due to more thought and planning on the part of the instructors of the department. Fifteen articles were published in engineering journals and proceedings of engineering societies last year, dealing with modern problems. Twelve notes and text books were also published for instructional purposes in this and other institutions of learning by members of this department.

CHANGES IN INSTRUCTIONAL STAFF

Three members of the department resigned to take up more responsible positions. Mr. J. L. Snyder, instructor in the Mechanical Laboratory, and Mr. H. L. Watson, Instructor in Machine Design, are now connected with commercial organizations, and Mr. R. L. Rhoades was called to Lehigh University as Instructor in the Mechanical Laboratory. The vacancies caused by these withdrawals have been filled, respectively by Mr. F. A. Hill, Iowa State College, 1913; Mr. F. C. Goldsmith, Purdue, 1910; and Mr. W. H. Severns, University of Kansas, 1914. The personnel of the instructional staff of this department numbers nine professors, six instructors and two assistants.

INTERESTING WORK NOW IN PROGRESS

At the present time some very interesting work is in progress. The new Diehl electric dynamometer in the gas laboratory makes possible some interesting work on internal combustion motors. The new six-cylinder Haynes motor is now being tested in comparison with a Haynes 12, now under construction at Kokomo. The completion of the belt testing machine makes the best apparatus of this kind ever constructed ready for use. An investigation is now under way in which five of the large pulley manufacturing companies are concerned. Work is still progressing on the flat spot machine, studying the amount of impact to the rail due to a flat spot or an eccentric car wheel. Another interesting study is being made for the New York Central Railroad to learn what effect the use of impure water has on the steaming properties of a locomotive boiler. A new freight locomotive was brought here and tested at Purdue University and is returning to the University every thirty days to be retested. This locomotive uses the same kind of water the other twenty-nine days during which it is on its regular run. This will be continued until the boiler is so badly scaled as not to be able to carry its allotted load.

Many other lines of work are in progress but the ones mentioned are creating the most interest in engineering circles.

The business policy of the *Review* in years past has been to get out a publication that would exactly break even financially. In several recent issues unlooked for expenditures arose, which meant that a debt had to be carried over from year to year to be met by the succeeding staff. This old debt was swept away by a special assessment on the Engineering Societies, so that the *Board* began the year unincumbered by any financial burden. It has been the very earnest endeavor of the *Board* to get out a publication this year that would be a success from a business standpoint, that would set a mark and a precedent for succeeding Boards to follow.

The *Review Board* desires to acknowledge the services of the following members of the Engineering Schools: C. L. Kline, Marvin Hummel, J. H. Emrick, Geo. Heidenreich, H. M. Benedict, O. W. Shepard, R. H. Bush, and to Mr. D. M. Evans of the School of Agriculture for valuable assistance rendered the Advertising Manager in the solicitation of advertising.

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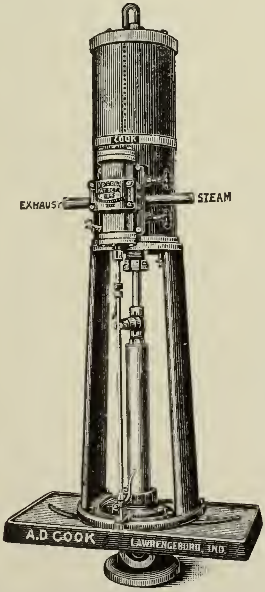

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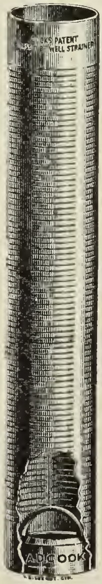

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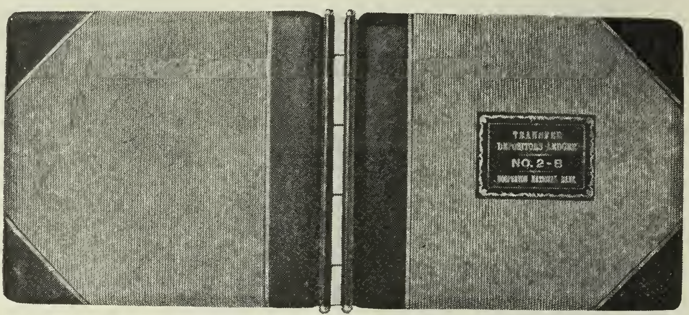

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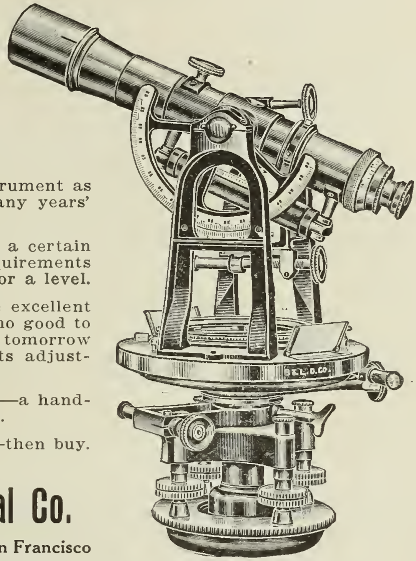

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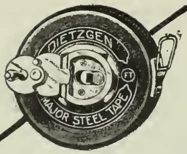

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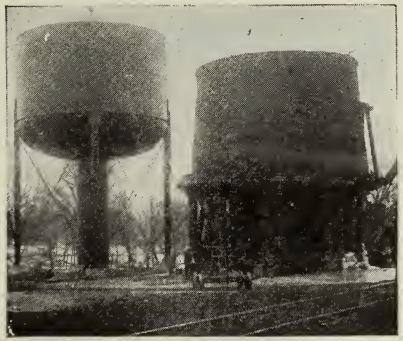

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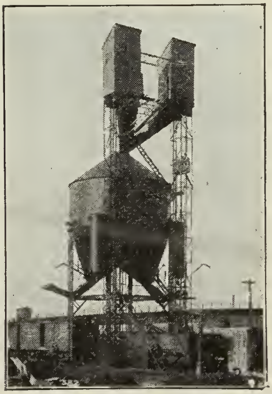

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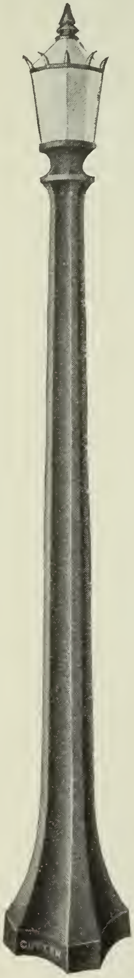

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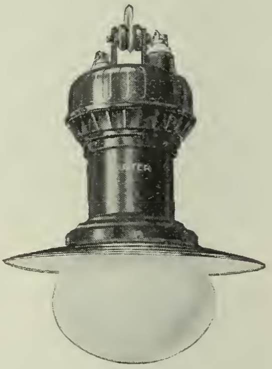

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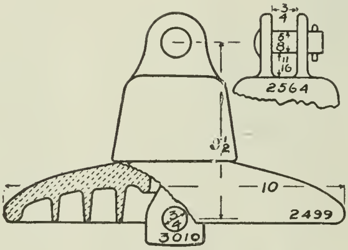

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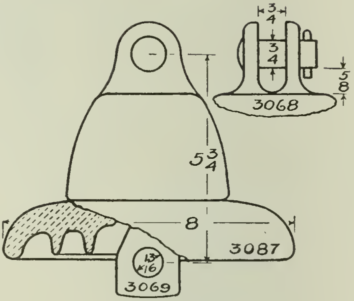

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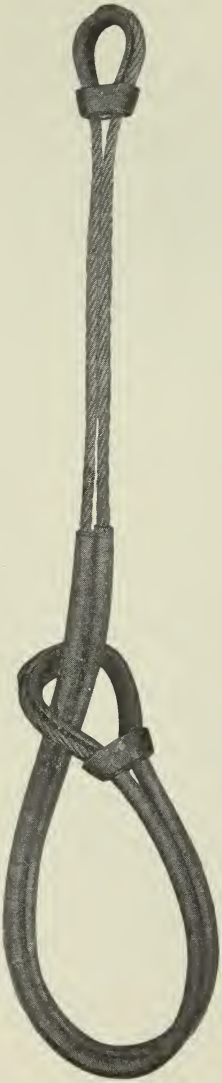

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